PALÆONTOGRAPHICAL SOCIETY.

VOL. LXII.

FOSSIL FISHES OF THE ENGLISH CHALK.

PART IV.

PAGES 129—152; PLATES XXVII—XXXII.

ILLUSTRATIONS OF TYPE SPECIMENS OF INFERIOR OOLITE AMMONITES.

PLATES I—VII; TITLE-PAGE.

THE CRETACEOUS LAMELLIBRANCHIA.

VOL. II, PART V.

PAGES 181—216; PLATES XXVIII—XXXIV.

THE BRITISH FOSSIL ECHINODERMATA.

VOL. II, PART V.

PAGES 133—138; TITLE-PAGE AND INDEX.

THE BRITISH CAMBRIAN TRILOBITES.

PART III.

PAGES 49—64; PLATES V, VI.

BRITISH GRAPTOLITES.

PART VII.

PAGES cxxi—cxlviii, 273—358; PLATES XXXII—XXXV.

ISSUED FOR 1908.

PALÆONTOGRAPHICAL SOCIETY.

VOLUME LXII.

CONTAINING

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DECEMBER, 1908.

THE PALÆONTOGRAPHICAL SOCIETY was established in the year 1847, for the purpose of figuring and describing British Fossils.

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Members desirous of forwarding the objects of the Society can be provided with plates and circulars for distribution on application to the Secretary, Dr. A. SMITH WOODWARD, British Museum (Nat. Hist.), South Kensington, London, S.W.

The following Monographs are in course of publication:

The Fossil Sponges, by Dr. G. J. Hinde.

The Graptolites, by Prof. Lapworth, Miss Elles, and Miss Wood.

The Cambrian Trilobites, by Mr. Philip Lake.

The Cretaceous Lamellibranchia, by Mr. H. Woods.

The Palæoniscid Fishes of the Carboniferous Formation, and the Fishes of the Old Red Sandstone, by Dr. R. H. Traquair.

The Fishes of the English Chalk, by Dr. A. Smith Woodward.

ANNUAL REPORT

OF THE

PALÆONTOGRAPHICAL SOCIETY, 1908,

WITH

LIST

OF

The Council, Secretaries, and Members

AND

A LIST OF THE CONTENTS OF THE VOLUMES ALREADY PUBLISHED.

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ANNUAL REPORT OF THE COUNCIL

FOR THE YEAR ENDING 31ST DECEMBER, 1907.

READ AND ADOPTED AT THE

ANNUAL GENERAL MEETING,

HELD AT THE APARTMENTS OF THE GEOLOGICAL SOCIETY, BURLINGTON HOUSE, 20TH MARCH, 1908.

DR. HENRY WOODWARD, F.R.S., PRESIDENT,

IN THE CHAIR.

THE Council, in presenting their Sixty-first Annual Report, have pleasure in recording another year's successful work. The volume for 1907, which was issued in December, is unusually varied, containing not only the ordinary contributions, but also a series of title-pages and indexes which were needful for the binding of several completed or discontinued Monographs. It comprises a small complete Monograph of "British Conulariæ," by Miss Ida L. Slater; and instalments of the Monographs of "Carboniferous Ganoid Fishes," by Dr. Traquair; of "English Chalk Fishes," by Dr. A. S. Woodward; of "Cretaceous Lamellibranchia," by Mr. H. Woods; of "Cretaceous Asteroidea," by Mr. W. K. Spencer; of "Cambrian Trilobites," by Mr. P. Lake; and of "British Graptolites," by the Misses Elles and Wood. The title-pages and indexes are for the Monographs of "Sirenoid Ganoids," by Prof. L. C. Miall; of "Inferior Oolite Ammonites," by Mr. S. S. Buckman; of "The Cornbrash Fauna," by the late Rev. J. F. Blake; and of the "Devonian Fauna of the South of England," Vols. II and III, by the Rev. G. F. Whidborne. For the preparation of the last-mentioned index the Council is indebted to Mr. Clement Reid, to whom thanks are due.

In their desire to comply with the frequent demands for the completion of unfinished works, the Council incurred an unusually large expenditure on letter-press printing and binding; and the total cost of the volume for 1907 exceeded the income for the year by the sum of £1 14*s*. 1*d*. The bill for binding, however, was not received in time to be paid before 31st December, so that the balance of £145 5*s*. 0*d*. with which the year began had actually risen to £200 16*s*. 10*d*. when it ended. This balance included a sum of £89 5*s*. 10*d*. received from the sale of back stock at the reduced rate decided upon in 1906; and it must be added that the Society was spared the expense of many illustrations. The Carnegie Trust for the Universities of Scotland was again so generous as to provide the five plates for the illustration of Dr. Traquair's Monograph of "Carboniferous Ganoid Fishes"; while Miss Slater and the Misses Elles and Wood presented all the original drawings for their Monographs. It is therefore clear that the subscriptions of members alone would have been far from sufficient to produce the publications issued to them. The Council would indeed welcome an accession of new subscribers to replace those who have recently been lost by death.

The thanks of the Society are due to the Council of the Geological Society for permission both to store the stock of back volumes and to hold the Council Meetings and the Annual General Meeting in their apartments.

In conclusion, it is proposed that the retiring members of Council be Miss Crosfield, Bishop Mitchinson, Dr. Kitchin, and Mr. Burrows; that the new members be Mrs. Longstaff, Mr. H. A. Allen, Dr. F. A. Bather, and Mr. William Hill; that the President be Dr. Henry Woodward; the Treasurer, Dr. G. J. Hinde; and the Secretary, Dr. A. Smith Woodward.

Annexed is the Balance-sheet.

The PALÆONTOGRAPHICAL SOCIETY in account with Dr. GEORGE J. HINDE, F.R.S., Treasurer.

Cr. *From January 1st, 1907, to December 31st, 1907.* *Dr.*

		£	s.	d.	£	s.	d.
Balance at Bank from last Account					145	5	0
Members' Subscriptions—1903–1906	26	27	6	0			
,, ,, 1907	358	375	18	0			
,, ,, 1908	10	10	10	0			
	394				413	14	0
Carriage paid by Members					1	13	5
Sales of back stock to Members					89	5	10
Sales by Messrs. Dulau & Co.					65	18	6
Repaid Income Tax (3 years)					2	5	0
Dividends on £500 Natal 3 per cent. Stock (less income tax)					14	5	0
Interest on Deposit in Bank					6	8	2
					£738	14	11

	£	s.	d.	£	s.	d.
Letterpress printing, Vol. LXI	186	12	2			
Paper	42	6	11			
				228	19	1
Drawing text-figures and making blocks	57	11	10			
Drawing plates	78	17	0			
Collotype and lithographic printing	95	8	3			
				231	17	1
Packing and distribution, Vol. LX				15	11	4
Secretary's honorarium				52	10	0
Postage and stationery				6	7	0
Fire Insurance				0	15	0
Petty charges				0	17	7
Returned subscription paid in error				1	1	0
Balance at Bank—Current Account	98	14	10			
,, ,, Deposit Account	100	0	0			
,, ,, Cheques not cleared	2	2	0			
				200	16	10
				£738	14	11

We have examined the above account, compared it with the vouchers, and find it to be correct; we have also seen the receipt for £500 Natal 3 per cent. Consolidated Stock.

John Hopkinson.
J. Allen Howe.
W. P. D. Stebbing.

LIST OF MEMBERS.*

CORRECTED TO 1st OCTOBER, 1908.

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* Members are requested to inform the Secretary of any errors or omissions in this list, and of any delay in the transmission of the Yearly Volumes.

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Manchester Literary and Philosophical Society, 36, George Street, Manchester.
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Munich Royal Library.

Nantwich Public Library.
New South Wales, Royal Society of, Sydney.
New York (U.S.A.) Public Library.
Newcastle-on-Tyne, Armstrong College.
Newcastle-on-Tyne, Literary and Philosophical Society of, Westgate Street, Newcastle-on-Tyne.
Newcastle-on-Tyne Public Library.
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CATALOGUE OF THE CONTENTS OF THE ANNUAL VOLUMES

ALREADY PUBLISHED BY

THE PALÆONTOGRAPHICAL SOCIETY.

Vol. I.	Issued March, 1848, for the Year 1847	The Crag Mollusca, Part I, Univalves, by Mr. S. V. Wood (pp. i—xii, 1—208, pls. i—xxi, and title-page).
.. II.	Issued July, 1849, for the year 1848	The Reptilia of the London Clay, Vol. I, Part I, Chelonia, &c., by Profs. Owen and Bell (pp. 1—76, pls. i—xxviii, viii A, x A, xiii A, xvi A, xviii A, xix*, xix B, xix C, xix D). The Eocene Mollusca, Part I, Cephalopoda, by Mr. F. E. Edwards (pp. 1—56, pls. i—ix).
.. III.[1]	Issued Aug., 1850, for the Year 1849	The Entomostraca of the Cretaceous Formations, by Mr. T. R. Jones (pp. 1—40, pls. i—vii). The Permian Fossils, by Prof. Wm. King (pp. i—xxxviii, 1—258, pls. i—xxviii*). The Reptilia of the London Clay, Vol. I, Part II, Crocodilia and Ophidia, &c., by Prof. Owen (pp. 1—68, pls. xxix, i—xvi, ii A). The Fossil Corals, Part I, Crag, London Clay, Cretaceous, by Messrs. Milne Edwards and Jules Haime (pp. i—lxxxv, 1—72, pls. i—xi).
.. IV.	Issued June, 1851, for the Year 1850	The Crag Mollusca, Part II, No. 1, by Mr. S. V. Wood (pp. 1—150, pls. i—xii). The Mollusca of the Great Oolite, Part I, Univalves, by Messrs. Morris and Lycett (pp. i—viii, 1—130, pls. i—xv). The Fossil Brachiopoda, Vol. I, Part III, No. 1, Oolitic and Liassic, by Mr. Davidson (pp. 1—64, pls. i—xiii).
.. V.	Issued June, 1851, for the Year 1851	The Reptilia of the Cretaceous Formations, by Prof. Owen (pp. 1—118, pls. i—xxxvii, vii A, ix A). The Fossil Corals, Part II, Oolitic, by Messrs. Milne Edwards and Jules Haime (pp. 73—146, pls. xii—xxx). The Fossil Lepadidæ, by Mr. Charles Darwin (pp. i—vi, 1—88, pls. i—v).
.. VI.	Issued Aug., 1852, for the Year 1852	The Fossil Corals, Part III, Permian and Mountain-limestone, by Messrs. Milne Edwards and Jules Haime (pp. 147—210, pls. xxxi—xlvi). The Fossil Brachiopoda, Vol. I, Part I, Tertiary, by Mr. Davidson (pp. 1—23, pls. i, ii). The Fossil Brachiopoda, Vol. I, Part II, No. 1, Cretaceous, by Mr. Davidson (pp. 1—54, pls. i—v). The Fossil Brachiopoda, Vol. I, Part III, No. 2, Oolitic, by Mr. Davidson (pp. 65—100, pls. xiv—xviii). The Eocene Mollusca, Part II, Pulmonata, by Mr. F. E. Edwards (pp. 57—122, pls. x—xv). The Echinoderms of the Crag, London Clay, &c., by Prof. E. Forbes (pp. i—viii, 1—36, pls. i—iv, and title-page).
.. VII.	Issued Dec., 1853, for the Year 1853	The Fossil Corals, Part IV, Devonian, by Messrs. Milne Edwards and Jules Haime (pp. 211—244, pls. xlvii—lvi). The Fossil Brachiopoda, Introduction to Vol. I, by Mr. Davidson (pp. 1—136, pls. i—ix). The Mollusca of the Chalk, Part I, Cephalopoda, by Mr. D. Sharpe (pp. 1—26, pls. i—x). The Mollusca of the Great Oolite, Part II, Bivalves, by Messrs. Morris and Lycett (pp. 1—80, pls. i—viii). The Mollusca of the Crag, Part II, No. 2, Bivalves, by Mr. S. V. Wood (pp. 151—216, pls. xiii—xx). The Reptilia of the Wealden Formations, Part I, Chelonia, by Prof. Owen (pp. 1—12, pls. i—ix).

[1] The Volume for the year 1849 consists of two separate portions, each of which is stitched in a paper cover, on which are printed the dates 1848, 1849, and 1850. The one portion contains 'Cretaceous Entomostraca' and 'Permian Fossils'; the other, 'London Clay Reptilia,' Part II, and 'Fossil Corals,' Part I.

CATALOGUE OF VOLUMES—Continued.

Vol. VIII.[1]	Issued May, 1855, for the Year 1854	The Fossil Brachiopoda, Vol. I, Part II, No. 2, Cretaceous (pp. 55—117, pls. vi—xii), with Appendix and Index to Vol. I, by Mr. Davidson (pp. 1—30, pl. A). The Reptilia of the Wealden Formations, Part II, Dinosauria, by Prof. Owen (pp. 1—54, pls. i—xix, xvi A). The Mollusca of the Great Oolite, Part III, Bivalves, by Messrs. Morris and Lycett (pp. 81—147, pls. ix—xv). The Fossil Corals, Part V, Silurian, by Messrs. Milne Edwards and Jules Haime (pp. 245—322, pls. lvii—lxxii). The Fossil Balanidæ and Verrucidæ, by Mr. Charles Darwin (pp. 1—44, pls. i, ii). The Mollusca of the Chalk, Part II, Cephalopoda, by Mr. D. Sharpe (pp. 27—36, pls. xi—xvi). The Eocene Mollusca, Part III, No. 1, Prosobranchiata, by Mr. F. E. Edwards (pp. 123—180, pls. xvi—xxiii).
„ IX.[2]	Issued Feb., 1857, for the Year 1855	The Mollusca of the Crag, Part II, No. 3, Bivalves, by Mr. S. V. Wood (pp. 217—342, pls. xxi—xxxi). The Reptilia of the Wealden Formations, Part III, by Prof. Owen (pp. 1—26, pls. i—xii). The Eocene Mollusca, Part III, No. 2, Prosobranchiata, continued, by Mr. F. E. Edwards (pp. 181—240, pls. xxiv—xxvii). The Mollusca of the Chalk, Part III, Cephalopoda, by Mr. D. Sharpe (pp. 37—68, pls. xvii—xxvii). The Tertiary Entomostraca, by Mr. T. R. Jones (pp. i—xii, 1—68, pls. i—vi). The Fossil Echinodermata, Oolitic, Vol. I, Part I, by Dr. Wright (pp. v—x, 1—154, pls. i—x).
„ X.	Issued April, 1858, for the Year 1856	The Fossil Echinodermata, Oolitic, Vol. I, Part II, by Dr. Wright (pp. 155—302, pls. xi—xxii). The Fossil Crustacea, Part I, London Clay, by Prof. Bell (pp. i—viii, 1—44, pls. i—xi). The Fossil Brachiopoda, Vol. II, Part IV, Permian, by Mr. Davidson (pp. 1—51, pls. i—iv). The Fossil Brachiopoda, Vol. II, Part V, No. 1, Carboniferous, by Mr. Davidson (pp. 1—48, pls. i—viii). The Reptilia of the Wealden Formations, by Prof. Owen, Part IV (pp. 8—26, pls. iv—xi), and Supplement No. 1 (pp. 1—7, pls. i—iii). The Reptilia of the London Clay, Vol. I (Supplement), by Prof. Owen (pp. 77—79, pls. xxviii A, xxviii B).
„ XI.	Issued Nov., 1859, for the Year 1857	The Fossil Echinodermata, Oolitic, Vol. I, Part III, by Dr. Wright (pp. 303—390, pls. xxiii—xxxvi). The Fossil Brachiopoda, Vol. II, Part V, No. 2, Carboniferous, by Mr. Davidson (pp. 49—80, pls. ix—xvi). The Reptilia of the Cretaceous Formations (Supplement No. 1), by Prof. Owen (pp. 1—19, pls. i—iv). The Reptilia of the Wealden Formations (Supplement No. 2), by Prof. Owen (pp. 20—44, pls. v—xii.) The Polyzoa of the Crag, by Prof. Busk (pp. i—xiv, 1—136, pls. i—xxii).
„ XII.	Issued March, 1861, for the Year 1858	The Fossil Echinodermata, Oolitic, Vol. I, Part IV, by Dr. Wright (pp. 391—468, pls. xxxvii—xliii). The Eocene Mollusca, Part III, No. 3, Prosobranchiata continued, by Mr. F. E. Edwards (pp. 241—330, pls. xxviii—xxxiii). The Reptilia of the Cretaceous Formations (Supplements No. 2, No. 3), by Prof. Owen (pp. 27—30, pl. vii, pp. 1—25, pls. i—vi). The Reptilia of the Purbeck Limestones, by Prof. Owen (pp. 31—39, pl. viii). The Fossil Brachiopoda, Vol. II, Part V, No. 3, Carboniferous by Mr. Davidson (pp. 81—120, pls. xvii—xxvi).
„ XIII.	Issued Dec., 1861, for the Year 1859	The Fossil Brachiopoda, Part V, No. 4, Carboniferous, by Mr. Davidson (pp. 121—210, pls. xxvii—xlvii). The Reptilia of the Oolitic Formations, No. 1, Lower Lias, by Prof. Owen (pp. 1—14, pls. i—vi). The Reptilia of the Kimmeridge Clay, No. 1, by Prof. Owen (pp. 15, 16, pl. vii). The Eocene Mollusca, Part IV, No. 1, Bivalves, by Mr. S. V. Wood (pp. 1—74, pls. i—xiii).

[1] This Volume is marked on the outside 1855.
[2] This Volume is marked on the outside 1856.

CATALOGUE OF VOLUMES—Continued.

Vol. XIV. Issued May, 1863, for the Year 1860	The Fossil Brachiopoda, Vol. II, Part V, No. 5, Carboniferous, by Mr. Davidson (pp. 211—280, pls. xlviii—lv). The Reptilia of the Oolitic Formations, No. 2, Lower Lias, by Prof. Owen (pp. 1—26, pls. i—xi). The Reptilia of the Kimmeridge Clay, No. 2, by Prof. Owen (pp. 27, 28, pl. xii). The Fossil Estheriæ, by Prof. Rupert Jones (pp. i—x, 1—134, pls. i—v). The Fossil Crustacea, Part II, Gault and Greensand, by Prof. Bell (pp. i—vii, 1—40, pls. i—xi).
,, XV. Issued May, 1863, for the Year 1861	The Fossil Echinodermata, Oolitic, Vol. II, Part I (Asteroidea), by Dr. Wright (pp. 1—130, pls. i—x, x A, xi, xii). Supplement to the Great Oolite Mollusca, by Dr. Lycett (pp. 1—129, pls. xxxi—xlv).
,, XVI. Issued Aug., 1864, for the Year 1862	The Fossil Echinodermata, Cretaceous, Vol. I, Part I, by Dr. Wright (pp. 1—64, pls. i—iii, iii A, iv—vii, vii A, viii, xi). The Trilobites of the Silurian, Devonian, &c., Formations, Part I (Devonian and Silurian), by Mr. J. W. Salter (pp. 1—80, pls. i—vi). The Fossil Brachiopoda, Vol. III, Part VI, No. 1, Devonian, by Mr. Davidson (pp. 1—56, pls. i—ix). The Eocene Mollusca, Part IV, No. 2, Bivalves, by Mr. S. V. Wood (pp. 75—136, pls. xiv—xx). The Reptilia of the Cretaceous and Wealden Formations (Supplement, No. 4), by Prof. Owen (pp. 1—18, pls. i—ix).
,, XVII. Issued June, 1865, for the Year 1863	The Trilobites of the Silurian, Devonian, &c., Formations, Part II, by Mr. J. W. Salter (pp. 81—128, pls. vii—xiv). The Fossil Brachiopoda, Vol. III, Part VI, No. 2, Devonian, by Mr. Davidson (pp. 57—131, pls. x—xx). The Belemnitidæ, Part I, Introduction, by Prof. Phillips (pp. 1—28). The Reptilia of the Liassic Formations, Part I, by Prof. Owen (pp. 1—40, pls. i—xvi).
,, XVIII. Issued April, 1866, for the Year 1864	The Fossil Echinodermata, Oolitic, Vol. II, Part II (Liassic Ophiuroidea), by Dr. Wright (131—154, pls. xiii—xviii). The Trilobites of the Silurian, Devonian, &c., Formations, Part III, by Mr. J. W. Salter (pp. 129—176, pls. xv—xxv). The Belemnitidæ, Part II, Liassic Belemnites, by Prof. Phillips (pp. 29—52, pls. i—vii). The Pleistocene Mammalia, Part I, Introduction, Felis spelæa, by Messrs. W. Boyd Dawkins and W. A. Sanford (pp. i—l, 1—28, pls. i—v). Title-pages, &c., to the Monographs on the Reptilia of the London Clay, Cretaceous, and Wealden Formations.
,, XIX.[1] Issued Dec., 1866, for the Year 1865	The Crag Foraminifera, Part 1, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady (pp. i—vi, 1—72, pls. i—iv). Supplement to the Fossil Corals, Part I, Tertiary, by Dr. Duncan (pp. i—iii, 1—66, pls. i—x). The Fossil Merostomata, Part I, Pterygotus, by Mr. H. Woodward (pp. 1—44, pls. i—ix). The Fossil Brachiopoda, Vol. III, Part VII, No. 1, Silurian, by Mr. Davidson (pp. 1—88, pls. i—xii).
,, XX. Issued June, 1867, for the Year 1866	Supplement to the Fossil Corals, Part IV, No. 1, Liassic, by Dr. Duncan (pp. i—iii, 1—44, pls. i—xi). The Trilobites of the Silurian, Devonian, &c., Formations, Part IV (Silurian), by Mr. J. W. Salter (pp. 177—214, pls. xxv*—xxx). The Fossil Brachiopoda, Vol. III, Part VII, No. 2, Silurian, by Mr. Davidson (pp. 89—168, pls. xiii—xxii). The Belemnitidæ, Part III, Liassic Belemnites, by Prof. Phillips (pp. 53—88, pls. viii—xx).
,, XXI. Issued June, 1868, for the Year 1867	Flora of the Carboniferous Strata, Part I, by Mr. E. W. Binney (pp. 1—32, pls. i—vi). Supplement to the Fossil Corals, Part IV, No. 2, Liassic, by Dr. Duncan (pp. 45—73, pls. xii—xvii). The Fossil Echinodermata, Cretaceous, Vol. I, Part II, by Dr. Wright (pp. 65—112, pls. ix, x, xii—xxi, xxi A, xxi B). The Fishes of the Old Red Sandstone, Part I, by Messrs. J. Powrie and E. Ray Lankester (pp. 1—32, pls. i—v). The Pleistocene Mammalia, Part II, Felis spelæa, continued, by Messrs. W. Boyd Dawkins and W. A. Sanford (pp. 29—124, pls. vi—xix).

[1] From 1865 onwards the Volumes are issued in two forms of binding: first, with all the Monographs stitched together and enclosed in one cover; secondly, with each of the Monographs separate, and the whole of the separate parts placed in an envelope. The previous Volumes are not in separate parts.

CATALOGUE OF VOLUMES—Continued.

Vol. XXII. Issued Feb., 1869, for the Year 1868

- Supplement to the Fossil Corals, Part II, No. 1, Cretaceous, by Dr. Duncan (pp. 1—26, pls. i—ix).
- The Fossil Merostomata, Part II, Pterygotus, by Mr. H. Woodward (pp. 45—70, pls. x—xv).
- The Fossil Brachiopoda, Vol. III, Part VII, No. 3, Silurian, by Mr. Davidson (pp. 169—248, pls. xxiii—xxxvii).
- The Belemnitidæ, Part IV, Liassic and Oolitic Belemnites, by Prof. Phillips (pp. 89—108, pls. xxi—xxvii).
- The Reptilia of the Kimmeridge Clay, No. 3, by Prof. Owen (pp. 1—12, pls. i—iv).
- The Pleistocene Mammalia, Part III, Felis spelæa, concluded, with F. lynx, by Messrs. W. Boyd Dawkins and W. A. Sanford (pp. 125—176, pls. xx—xxii, xxii A, xxii B, xxiii).

" XXIII. Issued Jan., 1870, for the Year 1869

- Supplement to the Fossil Corals, Part II, No. 2, Cretaceous, by Dr. Duncan (pp. 27—46, pls. x—xv).
- The Fossil Echinodermata, Cretaceous, Vol. I, Part III, by Dr. Wright (pp. 113—136, pls. xxii—xxix, xxix A, xxix B).
- The Belemnitidæ, Part V, Oxford Clay, &c., Belemnites, by Prof. Phillips (pp. 109—128, pls. xxviii—xxxvi).
- The Fishes of the Old Red Sandstone, Part I (concluded), by Messrs. J. Powrie and E. Ray Lankester (pp. 33—62, pls. vi—xiv).
- The Reptilia of the Liassic Formations, Part II, by Prof. Owen (pp. 41—82, pls. xvii—xx).
- The Crag Cetacea, No. 1, by Prof. Owen (pp. 1—40, pls. i—v).

" XXIV. Issued Jan., 1871, for the Year 1870

- The Flora of the Carboniferous Strata, Part II, by Mr. E. W. Binney (33—62, pls. vii—xii).
- The Fossil Echinodermata, Cretaceous, Vol. I, Part IV, by Dr. Wright (pp. 137—160, pls. xxx—xxxix).
- The Fossil Brachiopoda, Vol. III, Part VII, No. 4, Silurian, by Mr. Davidson (pp. 249—397, pls. xxxviii—l).
- The Eocene Mollusca, Part IV, No. 3, Bivalves, by Mr. S. V. Wood (pp. 137—182, pls. xxi—xxv).
- The Fossil Mammalia of the Mesozoic Formations, by Prof. Owen (pp. i—vi, 1—115, pls. i—iv).

" XXV. Issued June, 1872, for the Year 1871

- The Flora of the Carboniferous Strata, Part III, by Mr. E. W. Binney (pp. 63—96, pls. xiii—xviii).
- The Fossil Merostomata, Part III, Pterygotus and Slimonia, by Mr. H. Woodward (pp. 71—120, pls. xvi—xx).
- Supplement to the Crag Mollusca, Part I (Univalves), by Mr. S. V. Wood, with an Introduction on the Crag District, by Messrs. S. V. Wood, jun., and F. W. Harmer (pp. i—xxxi, 1—98, pls. i—vii, and map).
- Supplement to the Reptilia of the Wealden (Iguanodon), No. IV, by Prof. Owen (pp. 1—15, pls. i—iii).
- The Pleistocene Mammalia, Part IV, Felis pardus, &c., by Messrs. W. Boyd Dawkins and W. A. Sanford (pp. 177—194, pls. xxiv, xxv).
- The Pleistocene Mammalia, Part V, Ovibos moschatus, by Mr. W. Boyd Dawkins (pp. 1—30, pls. i—v).

" XXVI. Issued Oct., 1872, for the Year 1872

- Supplement to the Fossil Corals, Part III (Oolitic), by Prof. Duncan (pp. 1—24, pls. i—vii), with an Index to the Tertiary and Secondary Species.
- The Fossil Echinodermata, Cretaceous, Vol. I, Part V, by Dr. Wright (pp. 161—184, pls. xl—xliv).
- The Fossil Merostomata, Part IV (Stylonurus, Eurypterus, Hemiaspis), by Mr. H. Woodward (pp. 121—180, pls. xxi—xxx).
- The Fossil Trigoniæ, No. I, by Dr. Lycett (pp. 1—52, pls. i—ix).

CATALOGUE OF VOLUMES—Continued.

Vol. XXVII. Issued Feb., 1874, for the Year 1873

- The Fossil Echinodermata, Cretaceous, Vol. I, Part VI, by Dr. Wright (pp. 185—224, pls. xlv—lii).
- Supplement to the Fossil Brachiopoda, Vol. IV, Part I (Tertiary and Cretaceous), by Mr. Davidson (pp. 1—72, pls. i—viii).
- Supplement to the Crag Mollusca, Part II (Bivalves), by Mr. S. V. Wood (pp. 99—231, pls. viii—xi, and add. plate).
- Supplement to the Reptilia of the Wealden (Iguanodon), No. V, by Prof. Owen (pp. 1—18, pls. i, ii).
- Supplement to the Reptilia of the Wealden (Hylæochampsa), No. VI, by Prof. Owen (pp. 1—7).
- The Fossil Reptilia of the Mesozoic Formations, Part I, by Prof. Owen (pp. 1—14, pls. i, ii).

" XXVIII. Issued July, 1874, for the Year 1874

- The Post-Tertiary Entomostraca, by Mr. G. S. Brady, Rev. H. W. Crosskey, and Mr. D. Robertson (pp. i—v, 1—232, pls. i—xvi).
- The Carboniferous Entomostraca, Part I (Cypridinidæ), by Prof. T. Rupert Jones and Messrs. J. W. Kirkby and G. S. Brady (pp. 1—56, pls. i—v).
- The Fossil Trigoniæ, No. II, by Dr. Lycett (pp. 53—92, pls. x—xix).

" XXIX. Issued Dec. 1875, for the Year 1875

- The Flora of the Carboniferous Strata, Part IV, by Mr. E. W. Binney (pp. 97—147, pls. xix—xxiv).
- The Fossil Echinodermata, Cretaceous, Vol. I, Part VII, by Dr. Wright (pp. 225—264, pls. liii—lxii).
- The Fossil Trigoniæ, No. III, by Dr. Lycett (pp. 93—148, pls. xx—xxvii).
- The Fossil Reptilia of the Mesozoic Formations, Part II, by Prof. Owen (pp. 15—94, pls. iii—xxii).

" XXX. Issued Dec., 1876, for the Year 1876

- The Carboniferous and Permian Foraminifera (the genus Fusulina excepted), by Mr. H. B. Brady (pp. 1—166, pls. i—xii).
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- Supplement to the Reptilia of the Wealden (Poikilopleuron and Chondrosteosaurus), No. VII, by Prof. Owen (pp. 1—7, pls. i—vi).

" XXXI. Issued Feb., 1877, for the Year 1877

- Supplement to the Eocene Mollusca (Bivalves), by Mr. S. V. Wood, 2 plates.
- The Fossil Trigoniæ, No. IV, by Dr. Lycett (pp. 149—204, pls. xxviii—xl).
- The Eocene Mollusca (Univalves), Part IV, by Mr. S. V. Wood (pp. 331—361, pl. xxxiv).
- The Carboniferous Ganoid Fishes, Part I (Palæoniscidæ), by Dr. Traquair (pp. 1—60, pls. i—vii).
- The Fossil Reptilia of the Mesozoic Formations, Part III, by Prof. Owen (pp. 95—97, pls. xxiii, xxiv).
- The Fossil Elephants (E. antiquus), Part I, by Prof. Leith Adams (pp. 1—68, pls. i—v).

" XXXII. Issued Mar., 1878, for the Year 1878

- The Fossil Echinodermata, Cretaceous, Vol. I, Part VIII, by Dr. Wright (pp. 265—300, pls. lxii A, lxiii—lxix).
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- The Fossil Merostomata, Part V (Neolimulus, &c.), by Dr. H. Woodward (pp. 181—263, pls. xxxi—xxxvi, and title-page).
- Supplement to the Fossil Brachiopoda, Vol. IV, Part II, No. 2 (Jurassic and Triassic), by Mr. Davidson (pp. 145—242, pls. xvii—xxix).
- The Lias Ammonites, Part I, by Dr. Wright (pp. 1—48, pls. i—viii).
- The Sirenoid and Crossopterygian Ganoids, Part I, by Prof. Miall (pp. 1—32, pls. i, i A, ii—v).
- Supplement to the Reptilia of the Wealden (Goniopholis, Petrosuchus, and Suchosaurus), No. VIII, by Prof. Owen (pp. 1—15, pls. i—vi).
- The Pleistocene Mammalia, Part A (Preliminary Treatise), by Prof. Boyd Dawkins (pp. i—xxxviii).

CATALOGUE OF VOLUMES—Continued.

Vol. XXXIII. Issued May, 1879, for the Year 1879	The Eocene Flora, Vol. I, Part I, by Mr. J. S. Gardner and Baron Ettingshausen (pp. 1—38, pls. i—v). Second Supplement to the Crag Mollusca (Univalves and Bivalves), by Mr. S. V. Wood (pp. i, ii, 1—58, pls. i—vi, and title-page). The Fossil Trigoniæ, No. V, by Dr. Lycett (pp. 205—245, pl. xli, and title-page). The Lias Ammonites, Part II, by Dr. Wright (pp. 49—164, pls. ix—xviii). Supplement to the Reptilia of the Wealden (Goniopholis, Brachydectes, Nannosuchus, Theriosuchus, and Nuthetes), No. IX, by Prof. Owen (pp. 1—19, pls. i—iv). The Fossil Elephants (E. primigenius), Part II, by Prof. Leith Adams (pp. 69—146, pls. vi—xv).
,, XXXIV. Issued May, 1880, for the year 1880	The Eocene Flora, Vol. I, Part II, by Mr. J. S. Gardner and Baron Ettingshausen (pp. 39—58, pls. vi—xi). The Fossil Echinodermata, Oolitic, Vol. II, Part III (Asteroidea and Ophiuroidea), by Dr. Wright (pp. 155—203, pls. xix—xxi, pp. i—iv, and title-page). Supplement to the Fossil Brachiopoda, Vol. IV, Part III (Permian and Carboniferous), by Mr. Davidson (pp. 243—316, pls. xxx—xxxvii). The Lias Ammonites, Part III, by Dr. Wright (pp. 165—264, pls. xix—xl). The Reptilia of the London Clay, Vol. II, Part I (Chelone), by Prof. Owen (pp. 1—4, pls. i, ii).
,, XXXV. Issued May. 1881, for the Year 1881	The Fossil Echinodermata, Cretaceous, Vol. I, Part IX, by Dr. Wright (pp. 301—324, pls. lxx—lxxv). Supplement to the Fossil Brachiopoda, Vol. IV, Part IV (Devonian and Silurian, from Budleigh-Salterton Pebble Bed), by Mr. Davidson (pp. 317—368, pls. xxxviii—xlii). The Fossil Trigoniæ (Supplement No. 1), by Dr. Lycett (pp. 1—4). The Lias Ammonites, Part IV, by Dr. Wright (pp. 265—328, pls. xxii A, xxii B, xli—xlviii). The Reptilia of the Liassic Formations, Part III, by Prof. Owen (pp. 83—134, pls. xxi—xxxiii, and title-page). The Fossil Elephants (E. primigenius and E. meridionalis), Part III, by Prof. Leith Adams (pp. 147—265, pls. xvi—xxviii, and title-page).
,, XXXVI. Issued June, 1882, for the Year 1882	The Eocene Flora, Vol. I, Part III, by Mr. J. S. Gardner and Baron Ettingshausen (pp. 59—86, pls. xii, xiii, and title-page). Third Supplement to the Crag Mollusca, by the late Mr. S. V. Wood (pp. 1—24, pl. i). The Fossil Echinodermata, Cret., Vol. I, Part X, by Dr. Wright (pp. 325—371, pls. lxxvi—lxxx, and title-page). Supplement to the Fossil Brachiopoda, Vol. IV, Part V, by Dr. Davidson (pp. 369—383, and title-page). Do., Vol. V, Part I (Devonian and Silurian), by Dr. Davidson (pp. 1—134, pls. i—vii). The Lias Ammonites, Part V, by Dr. Wright (pp. 329—400, pls. xlix—lii, lii A, liii—lxix).
,, XXXVII. Issued Oct., 1883, for the Year 1883	The Eocene Flora, Vol. II, Part I, by Mr. J. S. Gardner (pp. 1—60, pls. i—ix). The Trilobites of the Silurian, Devonian, &c., Formations, Part V, by the late Mr. J. W. Salter (pp. 215—224, and title-page). The Carboniferous Trilobites, Part I, by Dr. H. Woodward (pp. 1—38, pls. i—vi). Supplement to the Fossil Brachiopoda, Vol. V, Part II (Silurian), by Dr. Davidson (pp. 135—242, pls. viii—xvii). The Fossil Trigoniæ (Supplement No. 2), by the late Dr. Lycett (pp. 5—19, pls. i—iv and title-page). The Lias Ammonites, Part VI, by Dr. Wright (pp. 401—440, pls. lxx—lxxvii).
,, XXXVIII. Issued Dec., 1884, for the Year 1884	The Eocene Flora, Vol. II, Part II, by Mr. J. S. Gardner (pp. 61—90, pls. x—xx). The Carboniferous Entomostraca, Part I, No. 2, by Prof. T. Rupert Jones, Mr. J. W. Kirkby, and Prof. G. S. Brady (pp. i—iii, 57—92, pls. vi, vii, and title-page). The Carboniferous Trilobites, Part II, by Dr. H. Woodward (pp. 39—86, pls. vii—x, and title-page). Supplement to the Fossil Brachiopoda, Vol. V, Part III, by Dr. Davidson (pp. 243—476, pls. xviii—xxi, and title-page). The Lias Ammonites, Part VII, by Dr. Wright (pp. 441—480, pls. lxxviii—lxxxvii).

CATALOGUE OF VOLUMES—Continued.

Vol. XXXIX. Issued Jan., 1886. for the Year 1885

- The Eocene Flora, Vol. II, Part III, by Mr. J. S. Gardner (pp. 91—159, pls. xxi—xxvii, and title-page).
- The Stromatoporoids, Part I, by Prof. Alleyne Nicholson (pp. i—iii, 1—130, pls. i—xi).
- The Fossil Brachiopoda (Bibliography), Vol. VI (pp. 1—163), by the late Dr. Davidson and Mr. W. H. Dalton.
- The Lias Ammonites, Part VIII, by the late Dr. Wright (pp. 481—503, pl. lxxxviii, and title-page).

,, XL. Issued Mar., 1887, for the Year 1886

- The Morphology and Histology of Stigmaria Ficoides, by Prof. W. C. Williamson (pp. i—iv, 1—62, pls. i—xv).
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- The Jurassic Gasteropoda, Part I, No. 1, by Mr. W. H. Hudleston (pp. 1—56).
- The Inferior Oolite Ammonites, Part I, by Mr. S. S. Buckman (pp. 1—24, pls. i—vi).
- The Pleistocene Mammalia, Part VI, by Prof. Boyd Dawkins (pp. 1—29, pls. i—vii).

,, XLI. Issued Jan., 1888, for the Year 1887

- The Fossil Sponges, Part II, by Dr. G. J. Hinde (pp. 93—188, pl. ix).
- The Palæozoic Phyllopoda, Part I, by Prof. T. R. Jones and Dr. Woodward (pp. 1—72, pls. i—xii).
- The Jurassic Gasteropoda, Part I, No. 2, by Mr. W. H. Hudleston (pp. 57—136, pls. i—vi).
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,, XLII. Issued Mar., 1889, for the Year 1888

- The Stromatoporoids, Part II, by Prof. Alleyne Nicholson (pp. 131—158, pls. xii—xix).
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- The Jurassic Gasteropoda, Part I, No. 3, by Mr. W. H. Hudleston (pp. 137—192, pls. vii—xi).
- The Inferior Oolite Ammonites, Part III, by Mr. S. S. Buckman (pp. 57—144, pls. xv, xxiii A).
- The Devonian Fauna of the South of England, Part I, by the Rev. G. F. Whidborne (pp. i, ii, 1—46, pls. i—iv).
- Title-pages and Prefaces to the Monographs on the Reptilia of the Wealden and Purbeck (Supplements), Kimmeridge Clay, and Mesozoic Formations, and on the Cetacea of the Red Crag.

,, XLIII. Issued Mar., 1890, for the Year 1889

- The Cretaceous Entomostraca (Supplement), by Prof. T. Rupert Jones and Dr. G. J. Hinde (pp. i—viii, 1—70, pls. i—iv).
- The Jurassic Gasteropoda, Part I, No. 4, by Mr. W. H. Hudleston (pp. 193—224, pls. xii—xvi).
- The Inferior Oolite Ammonites, Part IV, by Mr. S. S. Buckman (pp. 145—224, pls. xxiv—xxxvi).
- The Devonian Fauna of the South of England, Part II, by the Rev. G. F. Whidborne (pp. 47—154, pls. v—viii, viii A, ix—xv).

,, XLIV. Issued Apr., 1891, for the Year 1890

- The Stromatoporoids, Part III, by Prof. Alleyne Nicholson (pp. 159—202, pls. xx—xxv).
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- The Inferior Oolite Ammonites, Part V, by Mr. S. S. Buckman (pp. 225—256, pls. xxxvii—xliv).
- The Devonian Fauna of the South of England, Part III, by the Rev. G. F. Whidborne (pp. 155—250, pls. xvi—xxiv).
- Title-pages to the Supplement to the Fossil Corals, by Prof. Duncan.

,, XLV. Issued Feb., 1892. for the Year 1891

- The Jurassic Gasteropoda, Part I, No. 5, by Mr. W. H. Hudleston (pp. 225—272, pls. xvii—xx).
- The Inferior Oolite Ammonites, Part VI, by Mr. S. S. Buckman (pp. 257—312, pls. xlv—lvi).
- The Devonian Fauna of the South of England, Part IV (*Conclusion of* Vol. I) (pp. 251—344, pls. xxv—xxxi, and title-page).
- ,, ,, Vol. II, Part I, by the Rev. G. F. Whidborne (pp. 1—56, pls. i—v).

CATALOGUE OF VOLUMES—Continued.

Vol. XLVI.	Issued Nov., 1892, for the Year 1892	The Stromatoporoids, Part IV (*Conclusion*), by Prof. Alleyne Nicholson (pp. 203—234, pls. xxvi—xxix, and title-page). The Palæozoic Phyllopoda, Part II, by Prof. T. R. Jones and Dr. Woodward (pp. 73—124, pls. xiii—xvii). The Jurassic Gasteropoda, Part I, No. 6, by Mr. W. H. Hudleston (pp. 273—324, pls. xxi—xxvi). The Inferior Oolite Ammonites, Part VII, by Mr. S. S. Buckman (pp. 313—344, pls. lvii—lxxvi). The Devonian Fauna of the South of England, Vol. II, Part II, by the Rev. G. F. Whidborne (pp. 57—88, pls. vi—x).
,, XLVII.	Issued Dec., 1893, for the Year 1893	The Fossil Sponges, Part III, by Dr. G. J. Hinde (pp. 189—254, pls. x—xix). The Fossil Echinodermata, Cretaceous, Vol. II, Part II (Asteroidea), by Mr. W. Percy Sladen (pp. 29—66, pls. ix—xvi). The Inferior Oolite Ammonites, Part VIII, by Mr. S. S. Buckman (pp. 345—376, pls. lxxvii—xcii). The Devonian Fauna of the South of England, Vol. II, Part III, by the Rev. G. F. Whidborne (pp. 89—160, pls. xi—xvii).
,, XLVIII.	Issued Nov., 1894, for the Year 1894	The Jurassic Gasteropoda, Part I, No. 7, by Mr. W. H. Hudleston (pp. 325—390, pls. xxvii—xxxii). Carbonicola, Anthracomya, and Naiadites, Part I, by Dr. W. Hind (pp. 1—80, pls. i—xi). The Inferior Oolite Ammonites, Part IX, by Mr. S. S. Buckman (pp. 377—456, pls. xciii—ciii). The Fishes of the Old Red Sandstone, Part II, No. 1, by Dr. R. H. Traquair (pp. 63—90, pls. xv—xviii).
,, XLIX.	Issued Oct., 1895, for the Year 1895	The Crag Foraminifera, Part II, by Prof. T. R. Jones (pp. 73—210, pls. v—vii). The Jurassic Gasteropoda, Part I, No. 8, by Mr. W. H. Hudleston (pp. 391—444, pls. xxxiii—xl). Carbonicola, Anthracomya, and Naiadites, Part II, by Dr. W. Hind (pp. 81—170, pls. xii—xx). The Devonian Fauna of the South of England, Vol. II, Part IV, by the Rev. G. F. Whidborne (pp. 161—212, pls. xviii—xxiv).
,, L.	Issued Oct., 1896, for the Year 1896	The Crag Foraminifera, Part III, by Prof. T. R. Jones (pp. 211—314). The Jurassic Gasteropoda, Part I, No. 9, by Mr. W. H. Hudleston (pp. 445—514, pls. xli—xliv, and title-page). Carbonicola, Anthracomya, and Naiadites, Part III, by Dr. W. Hind (pp. 171—182, pl. xxi, and title-page). The Carboniferous Lamellibranchiata, Part I, by Dr. W. Hind (pp. 1—80, pls. i, ii). The Devonian Fauna of the South of England, Vol. III, Part 1, by the Rev. G. F Whidborne (pp. 1—112, pls. i—xvi).
,, LI.	Issued Dec., 1897, for the Year 1897	The Crag Foraminifera, Part IV, by Prof. T. R. Jones (pp. vii—xv, 315—402, and title-page). The Carboniferous Lamellibranchiata, Part II, by Dr. W. Hind (pp. 81—208, pls. iii—xv). The Carboniferous Cephalopoda of Ireland, Part I, by Dr. A. H. Foord (pp. 1—22, pls. i—vii). The Devonian Fauna of the South of England, Vol. III, Part II, by the Rev. G. F. Whidborne (pp. 113—178, pls. xvii—xxi).
,, LII.	Issued Dec., 1898, for the Year 1898	The Palæozoic Phyllopoda, Part III, by Prof. T. R. Jones and Dr. Woodward (pp. 125—176, pls. xviii—xxv). The Carboniferous Lamellibranchiata, Part III, by Dr. W. Hind (pp. 209—276, pls. xvi—xxv). The Inferior Oolite Ammonites, Part X, by Mr. S. S. Buckman (pp. i—xxxii, Suppl. pls. i—iv). The Carboniferous Cephalopoda of Ireland, Part II, by Dr. A. H. Foord (pp. 23—48, pls. viii—xvii). The Devonian Fauna of the South of England, Vol. III, Part III, by the Rev. G. F. Whidborne (pp. 179—236, pls. xxii—xxxviii).

CATALOGUE OF VOLUMES—Continued.

Vol. LIII.	Issued Dec., 1899, for the Year 1899	The Palæozoic Phyllopoda, Part IV, by Prof. T. R. Jones and Dr. Woodward (pp. i—xv, 175, 176, 177—211, pls. xxvi—xxxi, and title-page). The Cretaceous Lamellibranchia, Part I, by Mr. H. Woods (pp. 1—72, pls. i—xiv). The Carboniferous Lamellibranchiata, Part IV, by Dr. W. Hind (pp. 277—360, pls. xxvi—xxxix). The Inferior Oolite Ammonites, Part XI, by Mr. S. S. Buckman (pp. xxxiii—lxiv, pls. v—xiv).
,, LIV.	Issued Dec., 1900, for the Year 1900	The Cretaceous Lamellibranchia, Part II, by Mr. H. Woods (pp. 73—112, pls. xv—xix). The Carboniferous Lamellibranchiata, Part V, by Dr. W. Hind (pp. 361—476, pls. xl—liv). The Carboniferous Cephalopoda of Ireland, Part III, by Dr. A. H. Foord (pp. 49—126, pls. xviii—xxxii). The British Pleistocene Mammalia, Title-page for Vol. I, by Messrs. Dawkins and Sanford. The Structure of Carboniferous Plants, Title-page, by Mr. E. W. Binney.
,, LV.	Issued Dec., 1901, for the Year 1901	The Cretaceous Lamellibranchia, Part III, by Mr. H. Woods (pp. 113—144, pls. xx—xxvi). The Carboniferous Lamellibranchiata, Vol. II, Part I, by Dr. W. Hind (pp. 1—34, pls. i—vi), Title-page and Index for Vol. I. The Carboniferous Cephalopoda of Ireland, Part IV, by Dr. A. H. Foord (pp. 127—146, pls. xxxiii—xxxix). British Graptolites, Part I, by Miss Elles and Miss Wood, edited by Prof. Lapworth (pp. 1—54, pls. i—iv). Ganoid Fishes of British Carboniferous Formations—Part I, Palæoniscidæ, No. 2, by Dr. Ramsay H. Traquair (pp. 61—87, pls. viii—xviii).
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,, LVII.	Issued Dec., 1903, for the Year 1903	The Fishes of the English Chalk, Part II, by Dr. A. Smith Woodward (pp. 57—96, pls. xiv—xx). The Cretaceous Lamellibranchia, Part V, by Mr. H. Woods (pp. i—xliii, 197—232, pls. xxxix—xlii), Title-page and Index for Vol. I. The Carboniferous Lamellibranchiata, Vol. II, Part II, by Dr. W. Hind (pp. 35—124, pls. vii—xxi). The Carboniferous Cephalopoda of Ireland, Part V, by Dr. A. H. Foord (pp. 147—234, pls. xl—xlix), Title-page and Index. The Lower Palæozoic Trilobites of Girvan, Part I, by Mr. F. R. Cowper Reed (pp. 1—48, pls. i—vi). British Graptolites, Part III, by Miss Elles and Miss Wood, edited by Prof. Lapworth, (pp. xxix—lii, 103—134, pls. xiv—xix).
,, LVIII.	Issued Dec., 1904, for the Year 1904	The Fishes of the Old Red Sandstone, Part II, No. 2, by Dr. R. H. Traquair (pp. 91—118, pls. xix—xxvi). The Cretaceous Lamellibranchia, Vol. II, Part I, by Mr. H. Woods (pp. 1—56, pls. i—vii). The Carboniferous Lamellibranchiata, Vol. II, Part III, by Dr. W. Hind (pp. 125—216, pls. xxii—xxv). The Inferior Oolite Ammonites, Part XII, by Mr. S. S. Buckman (pp. lxv—clxviii, pls. xv—xix). The Lower Palæozoic Trilobites of Girvan, Part II, by Mr. F. R. Cowper Reed (pp. 49—96, pls. vii—xiii). British Graptolites, Part IV, by Miss Elles and Miss Wood, edited by Prof. Lapworth, (pp. liii—lxxii, 135—180, pls. xx—xxv).

CATALOGUE OF VOLUMES—Continued.

Vol. LIX. Issued Nov., 1905, for the Year 1905

- The Fossil Echinodermata, Cretaceous, Vol. II, Part III, by Mr. W. K. Spencer (pp. 67—90, pls. xvii—xxvi).
- The Cretaceous Lamellibranchia, Vol. II, Part II, by Mr. H. Woods (pp. 57—96, pls. viii—xi).
- The Carboniferous Lamellibranchiata, Vol. II, Title-pages and Index, by Dr. W. Hind.
- The Inferior Oolite Ammonites, Part XIII, by Mr. S. S. Buckman (pp. clxix—ccviii, pls. xx—xxiv).
- The Cornbrash Fauna, Part I, by the Rev. J. F. Blake (pp. 1—100, pls. i—ix).

,, LX. Issued Dec., 1906, for the Year 1906

- The Pleistocene Bears, by Prof. S. H. Reynolds (pp. 1—35, pls. i—viii).
- The Fishes of the Old Red Sandstone, Part II, No. 3, by Dr. R. H. Traquair (pp. 119—130, pls. xxvii—xxxi).
- The Cretaceous Lamellibranchia, Vol. II, Part III, by Mr. H. Woods (pp. 97—132, pls. xii—xix).
- The Lower Palæozoic Trilobites of Girvan, Part III, by Mr. F. R. Cowper Reed (pp. 97—186, Title-page and Index, pls. xiv—xx).
- The Cambrian Trilobites, Part I, by Mr. P. Lake (pp. 1—28, pls. i, ii).
- British Graptolites, Part V, by Miss Elles and Miss Wood, edited by Prof. Lapworth (pp. lxxiii—xcvi, 181—216, pls. xxvi, xxvii).

,, LXI. Issued Dec., 1907, for the Year 1907

- The Sirenoid Ganoids, Part II, by Prof. L. C. Miall (pp. 33—34, Title-page, Preface, and Postscript).
- Ganoid Fishes of British Carboniferous Formations, Part I, Palæoniscidæ, No. 3, by Dr. R. H. Traquair (pp. 87—106, pls. xix—xxiii).
- The Fishes of the English Chalk, Part III, by Dr. A. Smith Woodward (pp, 97—128, pls. xxi—xxvi).
- The Inferior Oolite Ammonites, Part XIV, by Mr. S. S. Buckman (pp. ccix—cclxii, Title-pages, Preface, and Index).
- The Cretaceous Lamellibranchia, Vol. II, Part IV, by Mr. H. Woods (pp. 133—180, pls. xx—xxvii).
- The Fossil Echinodermata, Cretaceous, Vol. II, Part IV, by Mr. W. K. Spencer (pp. 91—132, pls. xxvii—xxix).
- The British Conulariæ, by Miss Ida L. Slater (pp. 1—40, pls. i—v, Title-page and Index).
- The Cambrian Trilobites, Part II, by Mr. P. Lake (pp. 29—48, pls. iii, iv).
- British Graptolites, Part VI, by Miss Elles and Miss Wood (Mrs. Shakespear), edited by Prof. Lapworth (pp. xcvii—cxx, 217—272, pls. xxviii—xxxi).
- The Devonian Fauna of the South of England, Vol. II, Part V, and Vol. III, Part IV, by the Rev. G. F. Whidborne (Vol. II, pp. 215—222, Title-page and Index; Vol. III, pp. 237—247, Title-page and Index).
- The Cornbrash Fauna, Part II, by the Rev. J. F. Blake (pp. 101—102, Title-page and Index).

,, LXII. Issued Dec., 1908, for the Year 1908

- The Fishes of the English Chalk, Part IV, by Dr. A. Smith Woodward (pp. 129—152, pls. xxvii—xxxii).
- Illustrations of Type Specimens of Inferior Oolite Ammonites (pls. i—vii).
- The Cretaceous Lamellibranchia, Vol. II, Part V, by Mr. H. Woods (pp. 181—216, pls. xxviii—xxxiv).
- The Fossil Echinodermata, Cretaceous, Vol. II, Part V, by Mr. W. K. Spencer (pp. 133—138, Title-page and Index).
- The Cambrian Trilobites, Part III, by Mr. P. Lake (pp. 49—64, pls. v, vi.)
- British Graptolites, Part VII, by Miss Elles and Miss Wood (Mrs. Shakespear), edited by Prof. Lapworth (pp. cxxi—cxlviii, 273—358, pl. xxxii—xxxv).

Palæontographical Society, 1908.

THE

FOSSIL FISHES

OF THE

ENGLISH CHALK.

BY

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4. **Pachyrhizodus subulidens** (Owen). Plate XXVII; Text-figure 39.

1842. *Raphiosaurus subulidens*, R. Owen, Rep. Brit. Assoc., 1841, p. 190.
1842. *Raphiosaurus*, R. Owen, Trans. Geol. Soc. [2], vol. vi, p. 413, pl. xxxix, fig. 3.
1850. *Raphiosaurus lucius*, R. Owen, in Dixon, Geol. Sussex, p. 385, pl. xxxix, figs. 1—3.
1851. *Raphiosaurus subulidens*, R. Owen, Rept. Cret. Form. (Mon. Palæont. Soc.), p. 19, pl. x, figs. 5, 6.
1889. *Pachyrhizodus subulidens*, A. S. Woodward, Ann. Mag. Nat. Hist. [6], vol. iv, p. 351.
1901. *Pachyrhizodus subulidens*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 43, pl. vii, figs. 1, 2.

Type.—Anterior portion of maxilla; Sedgwick (Woodwardian) Museum, Cambridge.

Specific Characters.—A small species, the maxilla attaining a length of about 10 cm., the mandible about 15 cm. All teeth slender, very smooth, with the apex inwardly and backwardly curved. Maxilla flattened externally, with sockets for from 30 to 40 teeth; premaxilla expanded into a triangular facial lamina. Dentary bone very deep, but rapidly contracting in front into a narrow thickened symphysis; its outer face remarkably smooth, marked with two deep longitudinal depressions between which the middle part of the bone projects in a rounded longitudinal ridge; its total number of tooth-sockets not less than 30.

Description of Specimens.—The type specimen (Pl. XXVII, fig. 2), which is the anterior part of a left maxilla, was originally described by Owen as the dentary bone of a lizard. A similar maxilla of the right side has been found in association with part of a dentary (B. M. no. 38566), thus identifying the latter element; while another maxilla is associated with a clavicle and scales. These specimens prove that the head represented in Pl. XXVII, fig. 1, belongs to the same species.

In the latter fossil the cranium lacks the ethmoidal region and is incomplete behind on the right side, but it exhibits its principal characters when viewed from above (fig. 1 *a*). The external bones are nearly smooth, marked only in part by the radiating structural lines, which are most conspicuous in the depressed middle area of the frontal region. The supraoccipital (*socc.*) is exposed in a short and broad band at the back of the cranial roof, and bears a large median vertical crest on its hinder face. The epiotic (*epo.*) is also partially seen from above, forming a prominent angle. The parietal (*pa.*) is a small nearly square bone at the postero-external border of the frontal, widely separated from its fellow of the opposite side. The squamosal (*sq.*) is larger, but its precise shape and extent are not shown. Judging by appearances in the fracture on the right side, the parietal and squamosal join the hinder part of the frontal in forming the roof of an extensive posterior temporal fossa. The frontal bones (*fr.*) are especially large, and their shape and contour are well shown in fig. 1 *a*. They are constricted above the

hinder part of the eye, where their outer portion appears to be fused with the downwardly tapering postfrontal or sphenotic (*ptf.*). The cheek (fig. 1) is completely covered with thin plates, and the rather small eye has an ossified sclerotic. The postorbital plates (*po.*), three or four in number, are much elongated antero-posteriorly, and are traversed near the orbital border by the usual sensory canal, which is filled in the fossil with oxide of iron. There is a narrow suborbital plate (or series of plates), also traversed by the sensory canal (*so.*); and there is a short and deep antorbital (*ao.*), which appears to be thicker and less flattened than the others. A narrow plate which tapers to a point in front, slightly overlaps the hinder part of the maxilla and may probably be regarded as a supramaxilla. The characteristic maxilla (*mx.*), with its flattened outer face and nearly straight oral border, is also well seen, though imperfect behind and slightly overlapped above by the cheek-plates. Its long and stout antero-internal process is exposed by

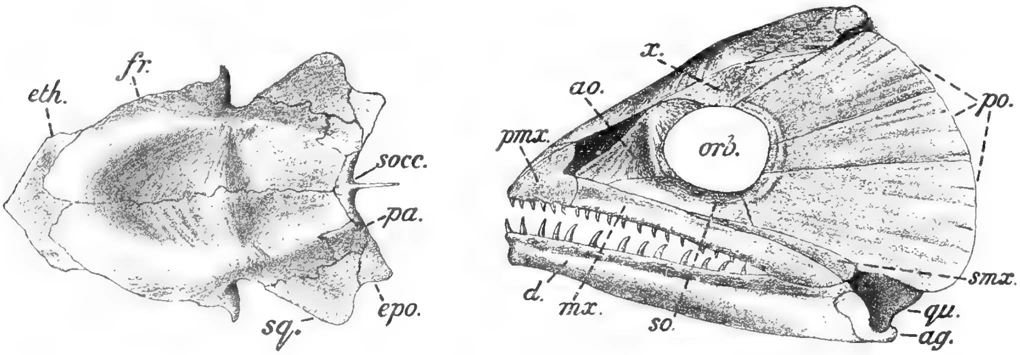


FIG. 39.—*Pachyrhizodus subulidens* (Owen); restored drawing of head, left lateral and upper aspects, about one half natural size.—English Chalk. *ag.*, angular; *ao.*, antorbital; *d.*, dentary; *epo.*, epiotic; *eth.*, mesethmoid; *fr.*, frontal; *mx.*, maxilla; *orb.*, orbit; *pa.*, parietal; *pmx.*, premaxilla; *po.*, postorbitals; *qu.*, quadrate; *smx.*, supramaxilla; *so.*, suborbital; *socc.*, supraoccipital; *sq.*, squamosal; *x.*, upper cheek-plate.

the accidental removal of the premaxilla. Its inner side is shown by another specimen (Pl. XXVII, fig. 3), in which the slender and slightly curved teeth are clearly flanked outside by a low thin wall of bone. Remains of the premaxilla occur in front of the maxilla just mentioned, showing the bases of the usual two large inner teeth, and suggesting that the bone was expanded into a deep lamina which occupied more of the face than the premaxilla in the preceding three species. The mandible occurs in position in the head already described (Pl. XXVII, figs. 1, 1 *b*), but it is so much fractured that the characters of the dentary are better shown in the original of Pl. XXVII, fig. 3 *a*. The symphysis tapers and is much thickened, but does not bear any teeth within the outer series. The outer face of the bone is remarkably smooth, and the longitudinal bulging of its middle portion is especially well seen in the right ramus (fig. 3 *a*), which is complete below. The teeth are very large compared with those of the maxilla, and their polished crowns curve backwards and inwards. Of the opercular apparatus it can only be said that the preoperculum (Pl. XXVII, fig. 1, *pop.*) is much expanded at the angle and apparently

smooth. Nine or ten broad branchiostegal rays (*br.*) are fixed to the epihyal (fig. 1 *b*, *eph.*), while traces of those fixed to the ceratohyal show that they must have been numerous. It is not known whether a gular plate was present or absent. The lower segments of the two halves of one branchial arch are fused with their basibranchial bone (*b.a.*).

The vertebral centra appear to exhibit a greater tendency towards slight pitting of the sides than those of the typical species.

The clavicle is characterised by a very wide inwardly-directed expansion (Pl. XXVII, fig. 1 *c*); and to its posterior border is appended a large postclavicular scale above the base of the pectoral fin.

A few thin scales associated with the maxilla shown in Pl. XXVII, fig. 3, are ornamented in their exposed sector with a very fine granulation and a few shallow and discontinuous radiating grooves (Pl. XXVII, fig. 4). Their extensive overlapped portion is smooth, without any radiating grooves.

Remarks.—This species is intermediate between the typical *Pachyrhizodus* and the typical *Thrissopater;* and it now seems probable that the occipital part of a small skull which I once referred to "*Thrissopater magnus*" (Catal. Foss. Fishes B. M., pt. iv, 1901, p. 35, pl. v, fig. 2) should be assigned to *Pachyrhizodus subulidens.*

Horizon and Localities.—Zone of *Holaster subglobosus:* Cherry Hinton, Cambridgeshire; Burham and Halling, Kent. Zone of *Schloenbachia varians:* Barton, Cambridgeshire.

5. **Pachyrhizodus** (?) **magnus,** A. S. Woodward. Plate XXVIII, fig. 1.

1901. *Thrissopater magnus,* A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 34, pl. v, fig. 1.

Type.—Imperfect head, probably from the zone of *Holaster subglobosus;* British Museum.

Specific Characters.—A species of uncertain generic position, apparently connected with *Pachyrhizodus* by *P. subulidens,* which is intermediate between this and the typical species. Length of maxilla about 7·5 cm., of mandible about 11 cm.; both these bones and the premaxilla resembling those of *P. subulidens.* Teeth unusually small, but of the characteristic shape and implantation. Median depression of cranial roof deep behind, but differing from that of the typical skull of *Pachyrhizodus* in not extending further forwards than the transverse ridge between the orbits.

Description of Specimen.—This species appears to be known only by the type specimen (Pl. XXVIII, fig. 1), which is vertically crushed so that the cheeks are displaced outwards, while the antorbital region is "faulted" by an oblique transverse fracture.

The most characteristic feature of the cranial roof is the median depression in

the hinder frontal region, where the bone becomes comparatively smooth. The small, finely punctate supraoccipital (*socc.*) is observable at the hinder border of the depression, while quite posteriorly, on the left side, the epiotic (*epo.*) is crushed outwards. The limits of the parietal (*pa.*), squamosal (*sq.*), and frontal (*fr.*) elements can also be distinguished. The frontals are very large as usual, and exhibit a longitudinal series of pits along either side of the depression, marking the course of the slime-canal. The terminal mesethmoid (*eth.*), finely punctate like the supraoccipital, is relatively small and pointed in front, without any expansion. The postorbital cheek-plates (*po.*), apparently three in number, are large and antero-posteriorly elongated, marked in their hinder portion with slightly radiating furrows, and traversed near the orbital border with the usual slime-canal. There is a long and narrow suborbital plate (*so.*), slightly excavated at its orbital border, nearly straight-edged below. The antorbital plate (*ao.*), which is broken by the fracture on the left side, but nearly complete on the right, is remarkably large, deep, and narrow. It is expanded into a triangular plate below, somewhat twisted about an oblique ridge at its middle, and then slightly expanded again at the upper end, where it forms part of the upper border of the orbit, and meets another plate in an oblique suture. The latter plate (*x.*) forms a small part of the orbital border, and tapers backwards while separating at least the anterior half of the upper postorbital from the edge of the cranial roof. A corresponding plate occurs in the existing *Elops* (Text-fig. 35, p. 112).

The premaxilla (*pmx.*), when viewed from the outer face, is triangular in shape, with a sharp notch in its short posterior border. It meets its fellow of the opposite side in front of the pointed mesethmoid. There are at least 15 tooth-sockets in its marginal series; and one larger tooth can be seen within on the comparatively small palatal extension of the bone. The maxilla (*mx.*) has a flattened and nearly smooth outer face, bevelled at the oral border, which exhibits many of the relatively small teeth. Throughout its hinder half it is overlapped by the single supramaxilla (*smx.*), which is also smooth, tapering in front and ending in a rounded expansion behind. The dentary bone of the mandible (*d.*) closely resembles that of *P. subulidens*, but bears only very small teeth. The articulo-angular bone (*ag.*), as usual, is quite short, and the articular facette for the quadrate (*qu.*) is on its lowest hinder portion.

Horizon and Locality.—Probably zone of *Holaster subglobosus:* Hollingbourn, Kent.

Genus **ELOPOPSIS**, Heckel.

Elopopsis, J. J. Heckel, Denkschr. k. Akad. Wiss., math.-naturw. Cl., vol. xi, 1856, p. 251.

Generic Characters.—Skull as in *Pachyrhizodus.* Teeth solid, robust, and conical, usually more or less laterally compressed, and enamelled nearly to the

base, where they are fused with the supporting bone; mandible with a single close series and an inner pair of relatively large teeth at the symphysis; premaxilla somewhat horizontally extended, bearing one or two relatively large teeth within the marginal series of very small teeth; maxilla robust, not much arched, with a single series of teeth which are smaller than those of the mandible. Vertebræ between 50 and 60 in number, the centra not longer than deep, all slightly constricted and marked with longitudinal ridges. Pelvic fins opposed to the dorsal; caudal fin forked. Scales large and delicate, deeply overlapping, their exposed portion smooth or marked only with slight longitudinal striæ or small shallow pittings.

Type Species.—Elopopsis fenzli (Heckel, *loc. cit.*, 1856, p. 251, pl. xiii, fig. 1), represented by a nearly complete fish in the Royal Court Museum, Vienna, from the Cretaceous (supposed Urgonian) of Comen, Istria.

Remarks.—The original specimens of this genus from Comen are crushed in fissile rock, and do not exhibit much of their cranial structure. More fragmentary specimens from the Chalk of Bohemia,[1] Westphalia,[2] and England display parts of the skull and jaws, with the dentition.

1. **Elopopsis crassus** (Dixon). Plate XXVIII, figs. 2—4.

1850. *Osmeroides crassus*, F. Dixon, Geol. Sussex, p. 376.
1888. *Osmeroides crassus*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 322.
1895. *Elopopsis crassus*, A. S. Woodward, Proc. Zool. Soc., 1894, p. 659, pl. xliii, fig. 1.
1901. *Elopopsis crassus*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 10.
1907. *Elopopsis crassus*, A. S. Woodward, The Naturalist, p. 306.

Type.—Imperfect head; Brighton Museum.

Specific Characters.—An imperfectly known large species, the mandible attaining a length of about 10 cm. Depth of head at occiput at least equalling length of cranium. Premaxilla elongate-triangular in shape, bearing a close series of small conical teeth on its oral border, and two much-enlarged teeth within, these somewhat laterally-compressed but without sharp edges; maxilla with gently convex oral border, bearing a regular series of small stout teeth, slightly largest on the middle of the convexity and decreasing in size backwards; mandible rapidly tapering to an almost pointed symphysis, with a series of laterally-compressed, not sharp-edged teeth, which are longest just in front of the middle of the ramus, and very small just behind the symphysis. The teeth generally marked with a few very fine vertical striæ.

[1] *Elopopsis heckeli*, A. E. Reuss, Denkschr. k. Akad. Wiss., math.-naturw. Cl., vol. xiii (1857), p. 39, pl. iii; A. Fritsch, Rept. u. Fische böhm. Kreideform. (1878), p. 41, fig. 61.

[2] *Elopopsis ziegleri*, W. von der Marck, Palæontogr., vol. xv (1868), p. 293, pl. xli, figs. 2—4.

Description of Specimens.—The type specimen in the Brighton Museum (Willett Collection, no. 61) comprises the head with the anterior part of the abdominal region of a large fish, much fractured and crushed, exhibiting part of the pectoral fin on the left side and part of the dorsal fin behind. The right side of the head is represented in Pl. XXVIII, fig. 2, an upper view of the ethmoidal region is given in fig. 2 *a*, and separate drawings of the left premaxilla and imperfect dentary are given in figs. 2 *b* and 2 *c*. There are more fragmentary specimens in the British Museum, two of these exhibiting a considerable portion of the trunk. There is also a specimen in the collection of Mr. Henry C. Drake, F.G.S., of Hull.

The superficial bones show no ornamentation, merely the lines of growth, and in places sensory canals. The cranial roof (so far as it can be examined in the type specimen and in B. M. no. P. 10218) appears to resemble that of *Pachyrhizodus* (Text-fig. 39), both in general contour and in the separation of the parietals by a small supraoccipital bone. The mesethmoid (Pl. XXVIII, fig. 2 *a*, *eth.*) is short and broad, truncated in front. The cheek is completely covered with thin bony plates, which are for the most part smooth and never tuberculated. There are three postorbitals (fig. 2, *po.*), which are marked only by inconspicuous radiating grooves and by the usual slime-canal, from which a few branches radiate backwards (B. M. no. P. 10320). The lowest postorbital, which is the largest, meets a long and narrow suborbital plate (*so.*), which rapidly tapers at each end and is only marked on the middle of its smooth outer face by a few ridges radiating apparently from the traversing slime-canal. The antorbital must have been small, but is unknown.

The mandibular suspensorium is nearly vertical, so that the quadrate articulation is beneath the occiput. The premaxilla (fig. 2, *pmx.*; fig. 2 *b*) is relatively small, elongate-triangular in shape, and does not meet its fellow of the opposite side in the median line, the wide mesethmoid intervening. On its oral margin the bone bears a single regular series of very stout, small, conical teeth, which are sometimes slightly inclined backwards and inwards. Within this outer row the premaxilla also bears one or two comparatively large, smooth, conical teeth. In the type specimen (fig. 2 *b*) the anterior inner tooth, shown only by the base, is the smaller of the two; while the well-preserved, posterior inner tooth occurs at about the middle of the bone. Both are somewhat laterally compressed, but not to sharp edges. The maxilla (fig. 2, *mx.*) is very large, extending backwards beyond the orbit, and overlapped above by a long and narrow supramaxilla (*smx.*), which tapers to a point in front. The upper border of the maxilla is notched near its anterior end just behind the prefrontal facette, and at the extremity of the suborbital cheek-plate; its oral border is gently convex and curves slightly inwards. The maxillary teeth resemble the teeth of the premaxilla, but, except at the anterior end, they are somewhat larger, and they are often distinctly

marked by vertical striations at the base (fig. 3 *b*). Behind the few foremost, the teeth are remarkably uniform in size, and in the gaps between them may be seen the points of developing successional teeth (Brit. Mus. no. P. 10337). Their apices are frequently blunt, as if worn. The dentary bone of the mandible is imperfect and not well seen in the type specimen (fig. 2 *c*), but is better shown by a comparatively small specimen (fig. 3). It tapers in front to an almost pointed symphysis, where it is thickened at the surface of contact with its fellow of the opposite side. The oral border of the bone is wavy in front, and the lower part of its outer face is traversed by a deep longitudinal groove, in which would probably lie the slime-canal. On the edge of the dentary there is a single series of sharply-pointed conical teeth, which are somewhat laterally compressed (though not to sharp edges), and marked with vertical striations (fig. 3 *a*). In the anterior convexity these teeth are quite small, but those of the rest of the series are much larger than the marginal teeth of the upper jaw. The developing successional teeth evidently alternate with those in function. The large inner symphysial tooth (seen in fig. 2 *c*, its base in fig. 3) is a little laterally compressed, but nearly round in section. Many sections of teeth are observable in the fossils and exhibit no trace of a pulp-cavity.

The bones of the opercular apparatus are remarkably thin, large, and smooth, showing only a slight waviness parallel with the margins. The preoperculum (fig. 2. *pop.*) is much expanded at the angle and in the lower limb, and bears marks of slime-canals which radiate backwards from the main slime-canal of its anterior border. The branchiostegal rays must have been numerous, in probably not less than 20 pairs, according to the type specimen, but only the hinder 14 pairs are satisfactorily known (B. M. no. P. 10320).

The vertebral centra (fig. 2 *d*) are strengthened by a few longitudinal ridges, which extend between the stout anterior and posterior rims. They are not much constricted, and none are longer than deep. The neural and hæmal arches in the caudal region are much flattened from side to side, and sharply inclined backwards.

In the pectoral arch, the clavicle, supraclavicle, and post-temporal are expanded into large, smooth plates, which are thin and readily flake in the fossils. There also appear to be enlarged postclavicular scales. The fins are almost unknown, but the base of the dorsal in B. M. no. P. 10217, shows that it was in the middle of the back, not remote.

The scales are large, thin, and very deeply overlapping, arranged in regular series. Their small exposed sector is sometimes quite smooth, sometimes impressed by very small pittings (fig. 4). The lateral line does not appear to form a ridge, but the canal traversed by it is conspicuous in flaked specimens.

Affinities.—In the characters of its maxillary dentition *E. crassus* agrees most closely with *E. ziegleri*, from the Cenomanian of Westphalia, but these two species apparently differ in their mandibular dentition.

Horizon and Localities.—Zone of *Rhynchonella cuvieri:* Wouldham, Kent (G. E. Dibley Coll.); South Ferriby, Lincolnshire (H. C. Drake Coll.). Probably zone of *Terebratulina gracilis:* Malling, near Lewes, Sussex. Probably also zone of *Schloenbachia varians:* Barrington, Cambridge (Sedgwick Museum).

Genus **THRISSOPATER**, Günther.

Thrissopater, A. Günther, Figs. and Descript. Brit. Organic Remains, dec. xiii (Mem. Geol. Surv., 1872), No. 1.

Generic Characters.—Trunk somewhat laterally compressed; abdomen compressed to an edge. Skull as in *Pachyrhizodus.* Teeth conical and enamelled nearly to the base, where they are fused with the supporting bone; a single series in the dentary, premaxilla, and maxilla. Premaxilla without inner horizontal extension; a single supramaxilla. Vertebræ about 50 in number, the centra rarely deeper than long, slightly constricted, smooth or delicately ridged. An enlarged postclavicular scale above the pectoral fin; pelvic fins opposed to the short dorsal; anal fin relatively small; caudal fin deeply forked. Scales small or of moderate size, usually ornamented with delicate radiating ridges; no enlarged or thickened ridge-scales; lateral line inconspicuous.

Type Species.—*Thrissopater salmoneus* (Günther, *loc. cit.*, 1872, no. 1, pl. i), from the Gault of Folkestone, Kent.

Remarks.—This genus appears to differ only very slightly from *Pachyrhizodus.* The dentition is more feeble, without inner teeth on the premaxilla. The trunk seems to have been less rotund.

A skull showing a gular plate, which I once assigned to *Thrissopater* (Catal. Foss. Fishes B. M., pt. iv, p. 33), now proves to belong to *Osmeroides.* The gular plate, therefore, still remains unknown.

1. **Thrissopater megalops**, A. S. Woodward. Plate XXVIII, fig. 5.

1901. *Thrissopater* (?) *megalops*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 35, pl. vii, fig. 4.

Type.—Imperfect head probably from zone of *Holaster subglobosus;* British Museum.

Specific Characters.—Posterior suborbital plates relatively narrow, their extent not exceeding one quarter the length of the skull; orbit very large, its width considerably greater than one third the length of the skull; teeth of premaxilla relatively long and slender, larger than those both of the maxilla and dentary. Opercular apparatus relatively narrow, its width not exceeding one third the length of the skull. Radiating lines on anterior scales few and indistinct.

Description of Specimen.—The only satisfactory specimen of this species hitherto discovered is the type (Pl. XXVIII, fig. 5). It is an imperfect head, broken in the rostral region, but sufficiently well preserved to exhibit its generic and specific characters. The typical constitution of the hinder part of the cranial roof is clearly seen, and there is the usual longitudinally-extended median depression. The comparatively short and deep postorbital cheek-plates (*po.*) are three in number; and above them there appears to have been another plate (*x.*) which extended forwards enough to meet the deep and narrow antorbital (*ao.*) above the large orbit. There is a single suborbital (*so.*) below the eye. A trace of an ossified sclerotic (*sc.*) is also seen. The premaxilla (*pmx.*) is a smooth narrow bar, with a prominence rising from its middle; its straight oral border bears very slender conical teeth, which are larger than the other upper and lower teeth. The maxilla (*mx.*) is also a smooth narrow bar, scarcely widening behind. Its teeth are comparatively short and stout, the hindmost slightly inclined forwards. The dentary bone (*d.*) is traversed on its outer face by a smooth, rounded, longitudinal ridge, as in some species of *Pachyrhizodus*. Remains of its conical teeth show that they had a large pulp-cavity. The remarkably short and deep opercular apparatus is nearly smooth, but most of the operculum (*op.*) is flaked away in the fossil. The expansion of the angle of the preoperculum (*pop.*) seems to have been less, and the relative depth of the suboperculum (*sop.*) greater than in the type species, *T. salmoneus*. In the pectoral arch the clavicle is imperfect; but the supraclavicle (*scl.*) and post-temporal (*ptt.*) are shown as expanded plates, nearly smooth, but feebly marked with radiating furrows and traversed by the usual slime-canal. The postclavicular scale (*pcl.*) and a few anterior scales are also ornamented with feeble radiating furrows.

Horizon and Locality.—Probably zone of *Holaster subglobosus:* near Lewes, Sussex.

Genus **PROTELOPS,** Laube.

Protelops, G. C. Laube, Denkschr. k. Akad. Wiss., math.-naturw. Cl., vol. 1, 1885, p. 286.

Generic Characters.—Teeth consisting of a long and slender hollow base tipped by a relatively small enamelled crown; of moderate size, more or less uniform, and not in sockets, but fused with the supporting bone; arranged in two or more series on the border of the mouth and on the pterygo-palatine arcade.

Type Species.—*Protelops geinitzi* (Laube, *loc. cit.*, p. 286, pl. i, fig. 1) from the Turonian of Prague, Bohemia.

1. **Protelops anglicus,** A. S. Woodward. Plate XXIX, figs. 1, 2.

1888. *Stratodus anglicus,* A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 314, pl. i, figs. 3, 4.
1901. *Protelops anglicus,* A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 57.

Type.—Imperfect jaws; British Museum.

Specific Characters.—Teeth of upper jaw slightly curved; those of dentary in two longitudinal series.

Description of Specimens.—This species is known only by fragments of jaws, which were originally referred to the Dercetid genus *Stratodus*, before the affinities of the latter were discovered.[1] The pieces of bone are remarkably thin and covered externally with a greenish-grey film. One long bone of the upper jaw, measuring 12 cm. in length, bears a dense cluster of the characteristic teeth (Pl. XXIX, fig. 1) from end to end. The anterior part of a dentary bone (fig. 2), which tapers to a blunt symphysis, exhibits the bases of attachment of two regular longitudinal series of similar teeth. The outer face of this bone is sculptured with a few irregular longitudinal grooves.

Horizon and Localities.—Zone of *Holaster subglobosus*: Glynde and Southeram, near Lewes, Sussex.

Family TOMOGNATHIDÆ.

An imperfectly definable extinct family, known only by skulls and other fragmentary remains from the Chalk. External head-bones somewhat thickened;

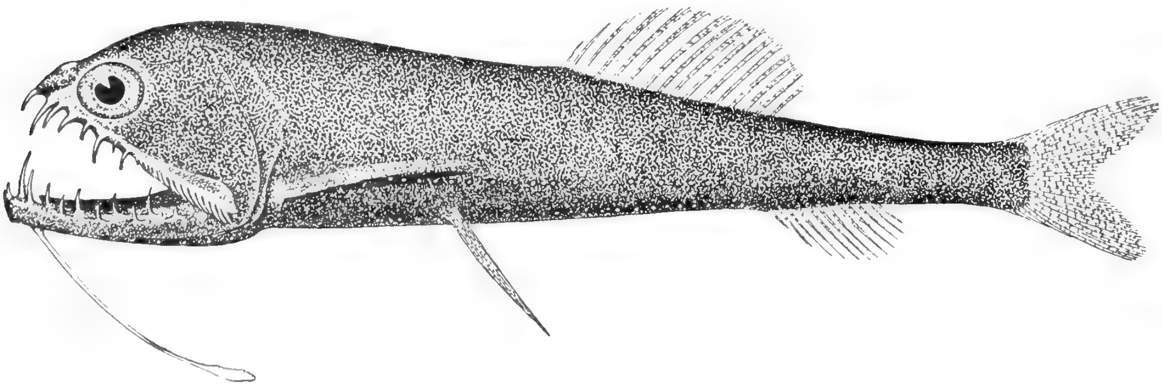


FIG. 40. *Astronesthes niger*, Richardson; about two thirds nat. size.—A Stomiatid fish existing in the Atlantic Ocean. After Goode and Bean.

supraoccipital very prominent and large, extending forwards and separating the parietals; ethmoidal region very short. Premaxilla and maxilla both entering the upper border of the mouth, the maxilla loose and with not more than one narrow supramaxilla; dentition powerful on margin of jaws. Opercular apparatus complete, but few branchiostegal rays and no gular plate.

In some respects the skull and dentition of *Tomognathus* are suggestive of those of the Stomiatidæ and their allies, which exist in the deep sea (Text-fig. 40).

[1] A. Stewart, "Teleosts of the Upper Cretaceous," Univ. Geol. Surv. Kansas, vol. vi, Palæont., pt. ii (1900), p. 327, pl. lx, pl. lxi, fig. 1. Also A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv (1901), p. 188.

Genus **TOMOGNATHUS,** Dixon.

Tomognathus, F. Dixon, Geol. Sussex, 1850, p. 376.

Generic Characters.—Head short and deep, much laterally compressed, with a thin supraoccipital crest extending along half its length; the orbit very large and far forwards; no cheek-plates. Cleft of mouth horizontal; dentigerous half of mandible slender, its hinder half deepened; teeth hollow and conical, enamelled only in their distal half, arranged in a close series, not in sockets but directly fused with the jaw; premaxillary and anterior dentary teeth the largest; a series of small teeth on the ectopterygoid, and another very small series within the conspicuous row of mandibular teeth.

Type Species.—*Tomognathus mordax,* from the English Chalk.

1. **Tomognathus mordax,** Dixon. Plate XXIX, figs. 3—13.

1850. *Tomognathus mordax,* F. Dixon, Geol. Sussex, p. 376, pl. xxxv, fig. 1.
1850. *Tomognathus leiodus,* F. Dixon, *op. cit.,* p. 377, pl. xxx, fig. 31. [Mandibular ramus: British Museum.]
1888. *Tomognathus mordax,* A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 313.
1901. *Tomognathus mordax,* A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 117.

Type.—Imperfect skull, with jaws.

Specific Characters.—The type and only known species, the head with opercular apparatus attaining a length of 7 cm. Orbit occupying nearly half the total length of the head, the maxilla nearly three and a half times as long as its maximum depth, and the mandibular ramus a little more than three times as long as its maximum depth. The robust premaxillæ fused together, and each bearing four large teeth gradually decreasing in size from the middle line to the side; these teeth scarcely tumid at the base, nearly straight, enamelled and faintly fluted in their distal half. None of the maxillary teeth more than half as large as the latter, very slender, and rapidly becoming small in the very close series behind; about eight teeth in the ectopterygoid series as large as the anterior maxillary teeth. Outer mandibular teeth closely similar to those of the premaxilla, but those at the symphysis a little more tumid at the base and incurved at the apex; the foremost tooth relatively small, the next three the largest, then another small one as the first of a diminishing series of about six to eight teeth. Width of operculum nearly equalling one quarter the length of the skull; suboperculum wider than deep; both destitute of superficial ornament.

Description of Specimens.—The type specimen appears to have been lost, but Dixon's figure shows the characteristic jaws and teeth, with the anterior half of

the skull, and part of the opercular apparatus. Numerous other skulls and jaws, especially those in the British Museum, are well preserved, but the trunk and fins remain almost unknown.

The cranium (Pl. XXIX, figs. 3—7) is deeper than wide, somewhat constricted just in front of the postfrontal (sphenotic) prominences, expanded again between the large orbits, and ending in a very short ethmoidal region. The bones of the cranial roof are a little thickened and of loose texture, without external ornament, and not clearly exhibiting the sutures between the constituent elements. A delicate median vertical supraoccipital crest (figs. 4, 7, *cr.*) extends forwards to the frontals (*fr.*), which are traversed by a shallow median longitudinal depression. The otic and prefrontal regions are completely ossified. The basicranial axis is almost parallel with the roof of the skull, as shown by the parasphenoid in fig. 5. The orbit is remarkably large, occupying nearly the front half of the head, and there are no traces of cheek-plates in any specimen. A small apparently superficial bone, however, hangs downwards and outwards from the hinder part of the outer border of the frontal. This bone (figs. 3, 7, *x*, and fig. 8) is smooth, narrow in its lower free half, triangularly expanded at its upper attachment.

The mandibular suspensorium is nearly vertical, so that the articulation of the mandible is beneath the occiput. The hyomandibular (figs. 5—7, *hm.*) is a much-expanded thin lamina of bone, strengthened by a vertical ridge on its outer face, and with a slight prominence for the support of the operculum. Its narrow truncated lower end appears to be completely behind the quadrate, but a symplectic has not been observed. The triangular quadrate (*qu.*) is relatively small, and its upper margin seems to be in contact only with the metapterygoid (*mpt.*), which does not bear any process for articulation with the cranium. The entopterygoid (*enpt.*) is a large, oval, delicate lamina of bone, without teeth. The ectopterygoid (*ecpt.*) is a long narrow bar at the lower border of the latter, bearing in its anterior half a single marginal row of conical teeth, which diminish in size backwards and are a little larger and stouter than most of those of the maxilla. On the middle of its inner face (fig. 9) the ectopterygoid also bears a few tubercular teeth. The premaxillæ (figs. 4—7, *pmx.*, and fig. 10) are very stout and almost, if not completely, fused together in the median line, besides being firmly fixed to the ethmoid. Each bears a close series of four large teeth, which slightly diminish in size backwards; and the bone is somewhat constricted above the dentigerous border, though the ascending portion is relatively wide and pierced by an oval foramen for the passage of the olfactory nerve (fig. 4). The maxilla (figs. 4—7, *mx.*) tapers to a slender portion in front, and is truncated, with a more or less jagged border, in its expanded portion behind. Its flat outer face exhibits a coarsely fibrous structure, and is rarely tuberculated (fig. 11); its slightly sinuous oral border bears a single close series of relatively small and slender teeth, which diminish in size backwards. If a supramaxilla was present, it must have been

single and narrow; but it has not been clearly observed. The mandible is much deepened in its hinder half, and the articulo-angular bone (figs. 5, 6, *ag.*) is relatively small and short, bearing the articular facette at a low level. The long and rounded coronoid elevation is formed entirely by the dentary (figs. 4—7, *d.*), which contracts into a stout narrow bar in its short tooth-bearing portion. This narrow bar, which is somewhat widened in a horizontal plane, curves inwards to meet its fellow of the opposite side at the symphysis. Its outer face is coarsely rugose and pitted, with one conspicuous longitudinal series of large pits, which is continued along the lower edge of the mandible behind, evidently marking the course of a well-developed slime-apparatus. The outer face of the large coronoid region is smooth. Three of the anterior mandibular teeth are much enlarged, like those of the premaxilla, but the tooth immediately at the symphysis is smaller, while those behind the large teeth rapidly diminish in size backwards. On the inner side of the principal mandibular teeth there is another regular close series of comparatively minute conical teeth, beginning at the symphysis and extending backwards beyond the outer series for some distance up the slope of the coronoid region (fig. 5). These small teeth are well shown in several specimens, but it is not clear whether they are borne by a separate splenial element. One imperfect mandible in the Bowerbank Collection (B. M. no. 39051) rather favours the latter supposition. All the teeth are hollow cones, not in sockets but directly fused with the supporting bone. They have smooth enamel, which does not extend to the base; and there are usually faint vertical flutings on the larger crowns (fig. 4 *a*).

The opercular apparatus is small and delicate, though complete and succeeded beneath by a few branchiostegal rays (at least six or seven in B. M. no. 49766). The preoperculum (fig. 6, *pop.*) is narrow and arcuate, not produced into a lower limb; its outer face is smooth and concave. The operculum (*op.*) and suboperculum (*sop.*) are also nearly smooth, though sometimes with a trace of coarse rugosity and tuberculation. No remains of a gular plate have been observed.

The trunk is almost unknown, but the fragmentary specimen shown in Pl. XXIX, fig. 13, suggests that the fish was long-bodied rather than fusiform. The vertebral centra have not been seen, and it is difficult to distinguish parts of vertebral arches from parts of fin-rays in fossils such as that just mentioned. The endoskeleton must have been feebly ossified, as is indicated by remains of some of the expanded hæmal elements at the base of the caudal fin (*c.*). The clavicle (fig. 12, *cl.*) tapers below and forwards, but is much expanded in its ascending portion, which appears to be short and sharply truncated at its upper end. The pectoral fin, of which the base is well shown in fig. 12, is relatively large and expanded. It comprises at least 19 rays, of which the foremost is the stoutest and is inserted by an expanded base which rises above the level of the other rays. The pelvic fins are unknown, but two feebly ossified elements shown in the middle of fig. 13, *plv.*, are suggestive of their bony supports. A few portions of fin-rays

in the same specimen probably represent remote dorsal and anal (*a.*) fins opposed to each other. The caudal fin (*c.*) consists of very stout, closely articulated, and finely divided rays; and their remains shown in fig. 13 suggest that it was not forked.

Variations.—In some of the jaws usually referred to *Tomognathus mordax*, the teeth are comparatively slender and exhibit scarcely any traces of the vertical flutings. These are of the form named *T. leiodus* by Dixon, but intermediate specimens appear to prevent their reference to a distinct species.

Horizon and Localities.—Zone of *Holaster subglobosus*: neighbourhood of Burham and Dover, Kent; Washington, Southeram (near Lewes), and Amberley (near Arundel), Sussex; Dorking, Surrey. The same or an allied species in the Chalk Marl (zone of *Schloenbachia varians*): Dover.

Sub-order ÆTHEOSPONDYLI.

Family ASPIDORHYNCHIDÆ.

This family is known only by two genera, *Aspidorhynchus* and *Belonostomus*. All the species of *Aspidorhynchus* (Text-fig. 41) are Jurassic, but a few of the larger species of *Belonostomus* occur in Cretaceous formations in Europe, Mexico, Brazil, and Queensland.

Genus **BELONOSTOMUS**, Agassiz.

Belonostomus, L. Agassiz, Neues Jahrb., 1834, p. 388.
Ophirachis, O. G. Costa, Ittiol. Foss. Ital., 1856, p. 13.

Generic Characters.—This genus differs from *Aspidorhynchus* (Text-fig. 41) in

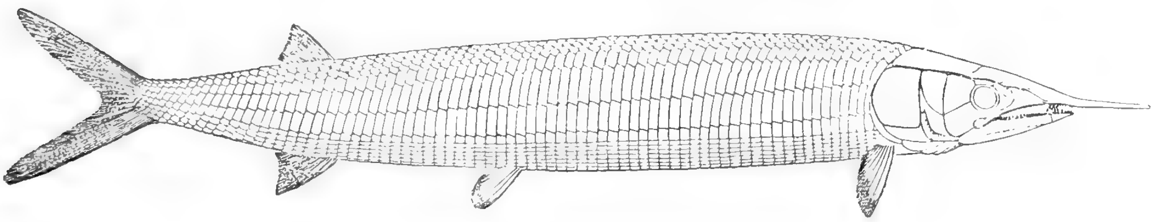


FIG. 41. *Aspidorhynchus acutirostris* (Blainville); restoration, about one seventh nat. size.—Upper Jurassic (Lithographic Stone); Bavaria. From Catal. Foss. Fishes B. M., pt. iii, 1895.

having the mandible almost, if not quite, as long as the rostrum, the postorbital cheek-plates in direct contact with the preoperculum, and all the scales of the lateral line deeper than those immediately beneath.

Type Species.—*Belonostomus sphyrænoides* (Agassiz, Poiss. Foss., vol. ii, pt. ii, 1844, pp. 140, 297, pl. xlvii *a*, fig. 5), from the Upper Jurassic Lithographic Stone of Bavaria.

1. **Belonostomus cinctus,** Agassiz. Plate XXX, figs. 1—7.

1837–44. *Belonostomus cinctus,* L. Agassiz, Poiss. Foss., vol. ii, pt. ii, p. 142, pl. lxvi *a*, figs. 10—13.
1850. *Belonostomus cinctus,* F. Dixon, Geol. Sussex, p. 367, pl. xxxv, figs. 3, 3*.
1850. *Belonostomus attenuatus,* F. Dixon, *ibid.*, p. 368, pl. xxxv, fig. 4. [Imperfect presymphysial bone; Brighton Museum.]
1888. *Belonostomus cinctus,* A. S. Woodward, Quart. Journ. Geol. Soc., vol. xliv, p. 145, pl. vii, figs. 7—13.
1895. *Belonostomus cinctus,* A. S. Woodward, Catal. Foss. Fishes B. M., pt. iii, p. 438.

Type.—Portion of squamation; British Museum.

Specific Characters.—Skull with very slender and slightly projecting rostrum, probably not less than 24 cm. in total length. Mandible also very slender, the presymphysial bone fifteen times as long as its maximum depth, keeled below, and overlapping the mandibular symphysis in an oblique suture. External face of rostrum and presymphysial bone sculptured with very fine longitudinal grooves, with intervening ridges, which are more or less irregular. Large teeth of the median series on the presymphysial bone, and those of the lateral series on the rostrum, sharply conical and well spaced; those on the splenial bone and some other elements obtuse and mammillated. Scales of flank smooth, those of the dorsal region marked with longitudinal rugæ; the scales of the lateral line truncated inferiorly and much exceeding in depth the series below, those on the anterior portion of the abdominal region being about four times as deep as broad.

Description of Specimens.—This species is still represented in collections only by fragments of the squamation and jaws. It is, however, definable, and the greater part of its mandible at least is well known. The type specimen, a piece of squamation in the Mantell Collection (No. 4266), is said to have been found in association with the fragment of upper jaw and presymphysial bone which were described with it by Agassiz.

The imperfect upper and lower jaws of a small individual, in natural association, are shown in Pl. XXX, fig. 1; and the greater part of the rostrum of a larger specimen is added in fig. 2. A very fragmentary piece of rostrum is also represented by Agassiz in his fig. 10, *loc. cit.* As shown by these and other specimens, the rostrum agrees with that of the typical Jurassic species of *Belonostomus* in being hollow and consisting of one continuous piece of bone, which is grooved along the middle of its oral face, and bears a single row of teeth along each lateral margin.[1] The bone is gently rotund, not compressed to a sharp ridge above, and fragments of it may thus be distinguished from those of the presymphysial bone described below. Its outer face is sculptured with fine grooves, which are mainly longitudinal, partly oblique; and the intervening ridges are not enamelled. Its terminal portion, which seems to have been toothless and

[1] See especially *Belonostomus dorsetensis,* A. S. Woodward, Catal. Foss. Fishes B. M., pt. iii (1895), p. 433, pl. xiv, fig. 2.

projected slightly beyond the mandible, shows a tendency to curve upwards in the original of fig. 2. The teeth on each margin are irregularly spaced, are largest above the hinder end of the presymphysial bone, and gradually decrease in size forwards until they disappear at some distance from the end of the snout. They are hollow slender cones, generally more or less recurved, coarsely crimped at the base, vertically striated, and capped by a sharp point of smooth translucent enamel (fig. 2 *a*). They are directly anchylosed with the bone of the jaw, not in sockets. Behind the rostrum, and opposed to the splenial dentition, is another bone (fig. 1, *x*) bearing shorter and stouter teeth of the same kind arranged in a very close series.

The best-known specimen of the mandible is shown from above in Pl. XXX, fig. 3, partly from the right side in fig. 3 *a*. The two rami occupy only one half the entire length of the jaw, the anterior half being formed by the enormously elongated presymphysial bone. Each ramus is laterally compressed and deep, gradually tapering in front; and the coronoid region rises immediately behind the posterior end of the tooth-bearing portion. The two rami meet in front in a very acute angle, and the symphysis is elongate, gradually diminishing to a thin edge below, and thus forming a sloping triangular surface for the overlap and articulation of the large presymphysial bone (see also figs. 1, 4). Anteriorly, for a very short space, the tooth-bearing margin is evidently formed by the dentary element (*d.*), but the greater part of this margin is occupied by the splenial (*spl.*), which gradually widens backwards. The presymphysial bone (*ps.*) is a median, bilaterally-symmetrical element, very gradually tapering to a point anteriorly. As shown in cross-section (fig. 4 *a*), it is hollow, compressed below into a sharp keel, and marked above by a shallow longitudinal channel. All the bones are ornamented, like the rostrum, with delicate longitudinal grooves and ridges, which tend to be most conspicuous near the ventral keel of the presymphysial bone. The only large teeth in the mandible form a single, widely-spaced series in the groove of the presymphysial bone. They are larger than those of the rostrum and are not recurved; but they are similarly hollow cones, with a smooth translucent tip of enamel, finely striated sides, and a crimped base anchylosed with the supporting bone (figs. 4 *b*, 5). The successional teeth are developed in the spaces between the actually functional teeth, so that the series is always more or less irregular. Very small teeth of the same kind, but stouter, are clustered along each lateral margin of the presymphysial bone, those of one inner series being slightly larger and more regular than the others. These marginal teeth are continued on the dentary, where it enters the oral border, and gradually pass into the splenial dentition, which is mainly adapted for crushing. Minute teeth extend far downwards on the inner side of the splenial, while larger mammilliform teeth are clustered in a pavement on the functional surface (figs. 3, 3 *b*).

The scales of the type specimen are exhibited partly from within, partly in impression of the outer face (Pl. XXX, fig. 6). Those traversed by the lateral line are smooth, with only the slightest trace of the usual vertical ridge and feeble marks of concentric growth-lines at the upper end. They are about four times as deep as wide in the part of the trunk preserved. The scales below this series appear to have been not deeper than wide, but the ventral scales are unfortunately crushed upon them. Here again there are only marks of concentric growth-lines. The rhombic dorsal scales, seen in another fragment (fig. 7), possibly even the upper ends of the flank-scales themselves, are ornamented with a few discontinuous ridges which run outwards from a low, smooth keel.

Horizons and Localities.—Turonian zones: neighbourhood of Lewes and Brighton, Sussex; Whyteleafe, Surrey; Folkestone, Kent. Zone of *Holaster subglobosus*: Burham and Dover, Kent.

Sub-order PROTOSPONDYLI.

Family PACHYCORMIDÆ.

Genus **PROTOSPHYRÆNA**, Leidy.

Protosphyræna, J. Leidy, Trans. Amer. Phil. Soc., vol. xi, 1857, p. 95.
Erisichthe, E. D. Cope, Proc. Acad. Nat. Sci. Philad., 1872, p. 280.
Pelecopterus, E. D. Cope, Vert. Cret. Form. West (Rep. U.S. Geol. Surv. Territ., vol. ii (1875), p. 244c.

Generic Characters.—An imperfectly definable genus known only by the head,

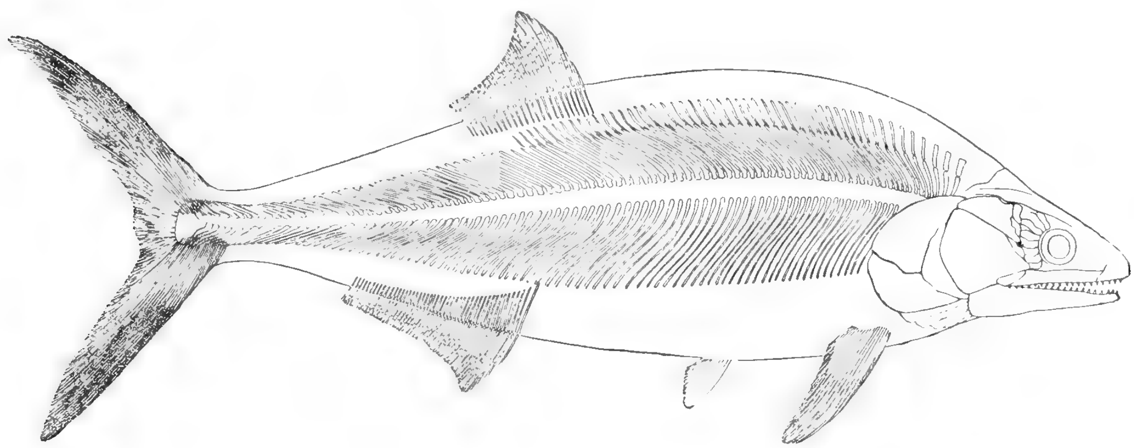


FIG. 42. *Hypsocormus insignis*, Wagner; restoration (without scales), about one fifth nat. size.—Upper Jurassic (Lithographic Stone); Bavaria. From Catal. Foss. Fishes B. M., pt. iii, 1895.

pectoral arch, and pectoral fins, which are closely similar to the corresponding parts of the Upper Jurassic genus *Hypsocormus* (Text-fig. 42). Rostrum ordinarily much produced; premaxilla large and triangular in shape. Dentition powerful,

all the principal teeth much compressed, with sharp anterior and posterior edges, and fixed in deep, complete sockets; those of the vomer, premaxilla, and splenial especially large, and similar teeth projecting forwards from the downwardly-curved anterior end of the oral border of the dentary; those of the maxilla and hinder portion of dentary comparatively small and in a single close series. Gular plate present, and short branchiostegal rays very numerous. Pectoral fins large and sickle-shaped, consisting of closely-apposed, unjointed and unbranched rays, of which the majority terminate successively at the oblique, trenchant anterior margin.

Type Species.—Protosphyræna ferox, from the English Chalk.

Remarks.—The remains of this genus were first discovered in the English Chalk. The teeth were originally referred by Agassiz[1] in error to *Saurocephalus* of Harlan,[2] while the pectoral fins were wrongly described as fin-rays of the Elasmobranch, *Ptychodus*.[3] The mistake in the identification of the teeth was first pointed out by Leidy (*loc. cit.*, 1857), who, however, failed to recognise that the elongated rostrum belonged to the same fish as these fossils. The pectoral fin-rays were first proved to be not Elasmobranch by Cope (*loc. cit.*, 1875), and their identity with *Protosphyræna* was subsequently determined both by Cope[4] and by Crook.[5] The head, pectoral arch, and pectoral fins (Text-fig. 43) are now comparatively well known by specimens from the Chalk of Kansas,

[1] L. Agassiz, Poiss. Foss., Feuill, 1835, p. 55.

[2] R. Harlan, Journ. Acad. Nat. Sci. Philad., vol. iii (1824), p. 337.

[3] L. Agassiz, Poiss. Foss., vol. iii (1837), p. 56.

[4] E. D. Cope, in A. S. Woodward, Proc. Geol. Assoc., vol. x (1888), p. 321.

[5] A. R. Crook, Palæontographica, vol. xxxix (1892), p. 110.

FIG. 43.—*Protosphyræna perniciosa* (Cope); pectoral fin, about one quarter nat. size.—Upper Cretaceous (Niobrara Group); Kansas, U.S.A. Charles H. Sternberg Collection (B. M. no. P. 10340).

U.S.A.;[1] but the notochordal trunk still remains to be discovered.[2] All the remains hitherto obtained from the English Chalk are fragmentary, and some can only be interpreted by reference to the American fossils. The species are distinguished by the form of the rostrum.

1. **Protosphyræna ferox,** Leidy. Plates XXXI, XXXII; Text-figure 45.

1822. "Undetermined," G. A. Mantell, Foss. South Downs, p. 228, pl. xxxiii, figs. 7—9.
1835–1844. *Saurocephalus lanciformis*, L. Agassiz (*errore*), Poiss. Foss., Feuill., p. 55, vol. v, pt. i, p. 102, pl. xxv *c*, figs. 21—29.
1844. *Saurocephalus lanceolatus*, L. Agassiz, *ibid.*, vol. v, pt. i, p. 8 (misprint).
1850. *Saurocephalus lanciformis*, F. Dixon, Geol. Sussex, p. 374, pl. xxx, fig. 21, pl. xxxi, fig. 12, pl. xxxii,* fig. 1, pl. xxxiv, fig. 11.
1857. *Protosphyræna ferox*, J. Leidy, Trans. Amer. Phil. Soc., vol. xi, p. 95.
1857. *Xiphias dixoni*, J. Leidy, *ibid.*, p. 95. [Rostrum; British Museum.]
? 1860. *Saurocephalus lanciformis*, V. Kiprijanoff, Bull. Soc. Imp. Nat. Moscou, vol. xxxiii, pt. i, p. 666, pl. x, fig. 4
1877. *Erisichthe dixoni*, E. D. Cope, Bull. U. S. Geol. Surv. Territ., vol. iii, p. 823.
1878. *Erisichthe dixoni*, W. Davies, Geol. Mag. [2], vol. v, p. 260, pl. viii, fig. 3.
1878. *Protosphyræna ferox*, E. T. Newton, Quart. Journ. Geol. Soc., vol. xxxiv, p. 789.
1888. *Protosphyræna ferox*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 321.
1895. *Protosphyræna ferox*, A. S. Woodward, Geol. Mag. [4], vol. ii, p. 211, woodc. fig. 3; and Catal. Foss. Fishes B. M., pt. iii, p. 400, text-fig. 41, no. 3.

Type.—Teeth; British Museum.

Specific Characters.—Rostrum much elongated and attaining a length of about 30 cm., with a transverse diameter of 5 cm. at its base, where the vomerine teeth are implanted; circular in transverse section throughout its whole length, except within a short distance of the vomerine teeth, where it becomes slightly flattened on the upper part of its sides and the top and passes into the gradually widening flattened cranial roof; its external surface ornamented with reticulating rugæ, of which the most prominent are longitudinally directed. Cranial roof more finely rugose and tuberculated. Teeth sometimes smooth, but usually with slight

[1] See especially J. Felix, "Beiträge zur Kenntniss der Gattung *Protosphyræna*, Leidy," Zeitschr. deutsch. geol. Gesell., vol. xlii (1890), pp. 278—302, pls. xii—xiv; F. B. Loomis, "Die Anatomie und die Verwandtschaft der Ganoid- und Knochen-Fische aus der Kreide-Formation von Kansas," Palæontogr., vol. xlvi (1900), pp. 215—228, pls. xix, xx; A. Stewart, "Teleosts of the Upper Cretaceous," Univ. Geol. Surv. Kansas, vol. vi, Palæont., pt. ii (1900), pp. 362—371, pls. lxii, lxiii; O. P. Hay, "On certain Genera and Species of North American Cretaceous Actinopterous Fishes," Bull. Amer. Mus. Nat. Hist., vol. xix (1903), pp. 2—26, pl. i.

[2] A portion of caudal region of a small fish from the Cretaceous of Mount Lebanon may perhaps belong to this genus (A. S. Woodward, Ann. Mag. Nat. Hist. [6], vol. xiii, 1894, p. 512). A fragment of a notochordal tail from the Chalk of Burham, Kent, in the Sedgwick Museum, may also be referable to *Protosphyræna*.

longitudinal wrinkles, which cause splits in the enamel of the fossils; the acute edges not serrated. Symphysial extremity of each dentary bearing three large teeth, and its oral border toothless where apposed to the dentigerous part of the splenial; splenial with two large teeth, and smaller teeth in front but none behind; vomerine teeth inclined backwards.

Description of Specimens.—The detached and imperfect teeth to which the name *Protosphyræna ferox* was originally given, are obviously insufficient for exact specific determination, but they agree well enough with those found in direct association with the long, round rostrum described in the foregoing diagnosis to be identified with it. They are the commonest teeth of *Protosphyræna* from the English Chalk, and are indeed likely to belong to *P. ferox* as now defined, because the long and round form of rostrum is much more abundant in the same deposit than the other forms described below.

As proved by a specimen from Cuxton, Kent, prepared by Mr. F. Harford (Brit. Mus., no. P. 5651), the middle of the cranial roof is flattened, shows no sutures, and is ornamented with a close network of fine ridges which tend to run most conspicuously in an antero-posterior direction, and are often subdivided or raised into rounded tubercles. The flattening of the roof is continued on the base of the rostrum, in front of the insertion of the vomerine teeth, and the characteristic reticular ornament extends forwards quite to the anterior end. The rostrum (Pl. XXXI, fig. 1) is straight and slightly directed upwards from the front of the skull. At its base (fig. 1 *a*) it is deeper than wide, with a flattening of the top as already described, and a constriction below in front of the vomerine teeth. At this point its upper half is hollow, and the inner cavity is divided by a vertical median partition. Further forwards the rostrum becomes round in section for the rest of its length; while the internal cavity soon loses its partition and becomes relatively larger (fig. 1 *b*), though eventually disappearing at some distance from the anterior end. The relatively small vomerine bones (*v.*) evidently form the elongate-triangular prominence on the lower face of the rostrum at its base, but they are so completely fused that their limits are indistinguishable. From the abrupt hinder face of the prominence a pair of rather short and broad teeth project with a backward inclination. These teeth are fixed in sockets, and are not always of equal size, suggesting that they were renewed by alternate development. They are best seen in a fragment described by W. Davies, *loc. cit.*, fig. 3.

The premaxilla (Pl. XXXI, figs. 2, 3) is not completely known, but it is elongate-triangular in shape, with the acute apex forwards. Its outer face (fig. 2) is flattened in front, slightly convex behind, and ornamented with a rugosity like that of the rostrum. The thickest part of the bone is the oral border (fig. 2*a*), where the wide ledge is pitted with at least seven deep and complete sockets for teeth. The teeth are largest in the middle of the bone,

longer and narrower than those of the vomer, and they generally slope forwards, though their direction is a little irregular. The maxilla (figs. 4, 5) is also incompletely known, but it has the form of a stout, narrow bar, with a flattened outer face, which is either rugose or tuberculated (fig. 5). Antero-internally it is produced into a large and stout process (figs. 4, 4*a*, *p.*). The oral border bears a close series of teeth in sockets, which are usually oval in section, often with the long axis oblique. The teeth diminish a little at each end of the series, but are otherwise nearly uniform in size, all small compared with those of the premaxilla. Their direction is either vertical or slightly inclined backwards.

Portions of the dentary bone, especially its anterior end, are associated with the rostrum shown in Pl. XXXI, fig. 1, *d.* The nearly complete mandible, of which the left ramus is shown in Pl. XXXI, fig. 6, is also directly associated with a typical rostrum. These specimens therefore prove that the anterior portion of a similar mandible figured by Dixon (*op. cit.*, pl. xxxi, fig. 12) and on Pl. XXXII, fig. 1, belongs to *P. ferox.* For the greater part of its length, the dentary bone (*d*) is a thin lamina somewhat bent on its long axis so that its outer face is convex, and slightly thickened at its upper border to form a ledge for the insertion of the teeth. Its outer face exhibits a fibrous texture, covered with some rugosity which becomes conspicuous towards the symphysis. The bone decreases in depth forwards to a point shortly behind the anterior extremity, and then expands again into a rounded end for the insertion of three large teeth where it meets its fellow in the tumid symphysis. These large teeth (Pl. XXXI, fig. 1, and Pl. XXXII, fig. 1) are the longest of any in the mouth, and project forwards from the rounded end of the dentary bone. They are fixed in deep sockets, and these are connected on their inner side with a groove in which the successional teeth develop (Pl. XXXII, figs. 1 *a*, 1 *b*). Immediately behind the large front teeth the constricted part of the dentary bone is toothless. Then follows a single regular series of comparatively small teeth, which diminish in size towards each end. On the inner face of the anterior end of the dentary there is a separate splenial element (*spl.*) which also enters the mandibular symphysis. It is thickest in front, tapers to a slender point behind, and suddenly deepens at its middle part to accommodate two large teeth which are implanted here. The large teeth are directed vertically or slightly backwards; a row of three or four diminutive teeth occurs in front of them, but the bone is toothless behind. This splenial element does not extend for more than half the length of the dentary; but behind it there must have been a posterior splenial in the form of a thin plate, tapering forwards and upwards, and covered with minute tubercular teeth. This bone is known in certain American species; and apparently one example of it from the zone of *Holaster subglobosus* at Amberley, near Arundel, occurs in the Capron Collection (B. M. no. 49827), though the specimen is unfortunately isolated.

The teeth (Pl. XXXI, figs. 7, 8) are solid, bilaterally symmetrical, and com-

pressed to a pair of sharp edges, which are not serrated. Their enamelled surface is vertically wrinkled or striated, and often cracks along the fine lines thus formed. In transverse section, when viewed with a microscope (fig. 8) they are shown to be composite, consisting of crowded tubules of irregular size and shape. From the central canal of each tubule there radiate numerous branching canaliculi. The successional tooth appears directly below the functional tooth, and produces a cavity by absorption in the side of the base of the latter (fig. 7, *s.*).

Of the axial skeleton of the trunk nothing is definitely known, but there cannot be much doubt that a peculiar form of hypural bone found in the Chalk, Gault, and Cambridge Greensand, is rightly referred to *Protosphyræna* (W. Davies, *loc. cit.*, 1878, p. 256). The specimens from the Chalk must belong chiefly to *P. ferox*. One such hypural has actually been found partly overlapped by the rays of the lower lobe of the fin, and is shown in Pl. XXXII, fig. 2. An isolated specimen from the Cambridge Greensand is represented for comparison in fig. 3. Though laterally compressed, the bone is slightly tumid at the sides, and it is marked by feeble, nearly vertical grooves to accommodate the deeply-overlapping caudal fin-rays (*r.*). It is usually more than twice as deep as wide, with rounded angles; and the middle of the posterior border is compressed to a sharp edge. It obviously represents a single, enormously-expanded hæmal arch, and its base appears as a relatively small process (*p.*) above the middle point of its anterior border. Above this process the anterior border is excavated by a longitudinal groove.

The fins of *Protosphyræna* hitherto discovered in the English Chalk are all fragmentary and isolated, but most of them agree more or less closely with the pectoral fins of *P. perniciosa* from the Chalk of Kansas (Text-fig. 43, p. 146) and probably represent the pectorals of *P. ferox*. Their undivided rays are firmly pressed together and successively terminate at the sharp front border, which is almost straight near the base, but soon becomes wavy further down, and eventually rises into a row of triangular teeth (Pl. XXXII, fig. 4). For the most part the rays are smooth, but at the front border they are finely rugose, with the rugæ directed transversely. At the straight base of insertion of the fin, the right and left halves of the rays diverge to clasp the baseosts, of which there are eight. The foremost baseost (Pl. XXXII, figs. 5, 5 *a*, I; also seen in Brit. Mus. no. P. 4507 *a*) is short and stout, deeply pressed between the rays, inclined towards the outer or upper side, and hollowed at its summit into a regular circular cup for articulation with a rounded prominence on the scapula (Text-fig. 44). The second baseost (described as a pair in the specimens from the American Chalk) is a quadrangular plate (figs. 5, 5 *a*, II) nearly twice as wide as deep, fixed at right angles to the plane of the fin, attenuated in the middle, and unequally thickened at its extremities, where it articulates with the pectoral arch in two separate flattened facettes, of which the inner or lower is the larger. The

third to the eighth baseosts (all except the foremost being well seen in Pl. XXXII, figs. 6, 6 *a*) are a regular series of stout bars, expanded at their lower end at right angles to the plane of the fin, and articulating at their upper end with a row of six shallow pits in a flat surface of the pectoral arch. This arrangement was first described by Cope,[1] but the pectoral arch itself was not correctly interpreted until Hay[2] compared it with the corresponding arch in the existing *Megalops*. As shown by American fossils, and by several more imperfect specimens from the Cambridge Greensand, the elements within the clavicle are completely fused together, and in addition to the scapula (*sc.*) and coracoid (*cor.*) there is a well-developed precoracoid bar (*pc.*).

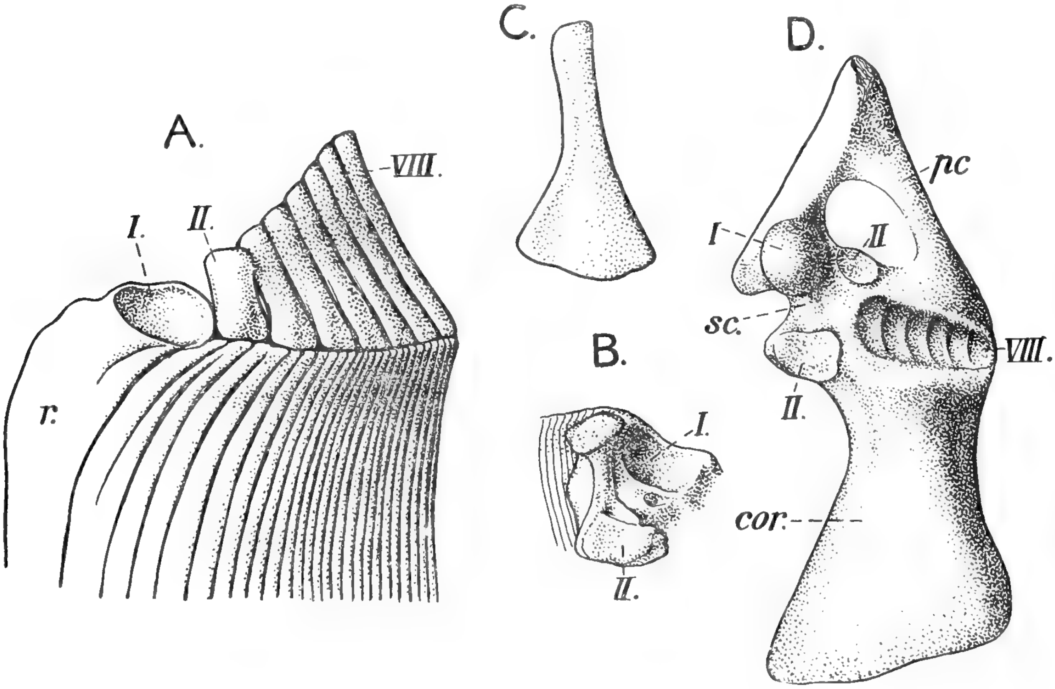


FIG. 44. Diagram of left pectoral arch and base of pectoral fin of *Protosphyræna*. A. Upper view of base of fin; B. end view of preaxial part of same; C. eighth baseost, inner view; D. pectoral arch, outer view. *cor.*, coracoid; *pc.*, precoracoid; *r.*, preaxial fin-ray; *sc.*, scapula; I, II, VIII, baseosts and (in D.) facettes for the same.

Most of the fragments of pectoral fins ascribed by Agassiz[3] to *Ptychodus* doubtless belong to this species. Basal portions are named *Ptychodus arcuatus* (*loc. cit.*, p. 58, pl. x *a*, fig. 2); more distal portions are named *P. spectabilis* (*loc. cit.*, p. 57, pl. x *a*, fig. 1); while small specimens and fragments of distal end are referred to *P. gibberulus* (*loc. cit.*, p. 58, pl. x *a*, fig. 4). The type specimen of the so-called *Ptychodus articulatus* (*loc. cit.*, p. 58, pl. X *a*, figs. 5, 6) is probably part of the caudal fin of a fish of the family Chirocentridæ.

[1] E. D. Cope, "Vertebrata of the Cretaceous Formations of the West," Rep. U. S. Geol. Surv. Territ., vol. ii (1875), p. 244 A.

[2] O. P. Hay, Bull. Amer. Mus. Nat. Hist., vol. xix (1903), p. 11.

[3] L. Agassiz, Poiss. Foss., vol. iii, 1837, p. 56.

Horizons and Localities.—Turonian zones: neighbourhood of Lewes, Sussex; Cuxton, Kent; Guildford, Surrey. Zone of *Holaster subglobosus:* Burham and Wouldham, Kent; Glynde and Amberley, Sussex; Dorking and Merstham, Surrey. Also Cambridge Greensand.

2. **Protosphyræna compressirostris,** A. S. Woodward. Text-figure 45.

1895. *Protosphyræna compressirostris,* A. S. Woodward, Geol. Mag. [4], vol. ii, p. 213, woodc. fig. 2; and Catal. Foss. Fishes B. M., pt. iii, p. 405, text-fig. 41, no. 2.

Type.—Rostrum; British Museum.

Specific Characters.—Rostrum much elongated and attaining a length of at least 19 cm., with a transverse diameter of 2 cm. at its base, where the vomerine teeth are implanted; laterally compressed in its proximal half, the transverse section here being an oval with vertical long axis; circular in transverse section in its distal portion, the top of the base gradually becoming flattened as it passes into the cranial roof. External ornament as in *P. ferox*.

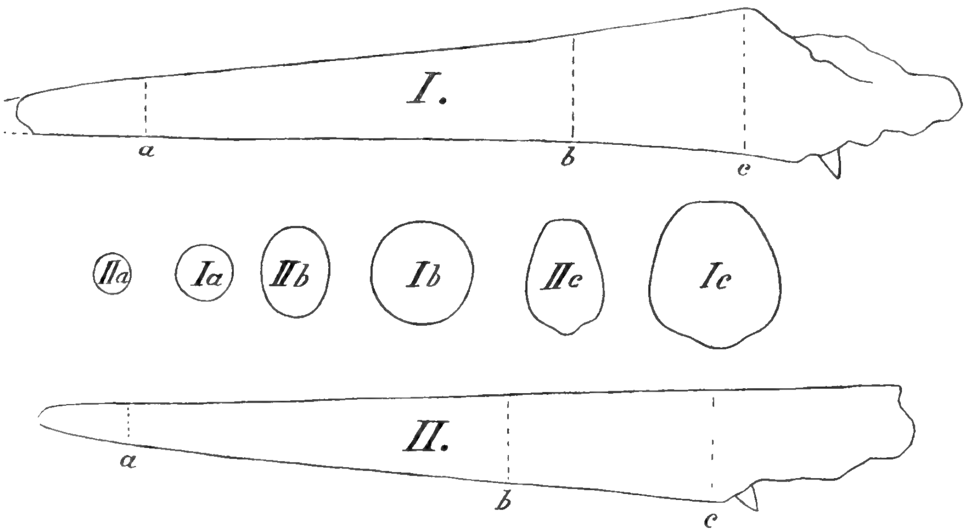


Fig. 45. Outlines of Rostra of *Protosphyræna ferox*, Leidy (I), and *Protosphyræna compressirostris*, A. S. Woodward (II), in side view and transverse sections, one half nat. size.—Chalk; Kent. Harford Collection (B. M. nos. P. 5630, 5631).

Remarks.—This species is known only by one rostrum, which differs from that of *P. ferox* in the lateral compression of its proximal half.

Horizon and Locality.—Unrecorded, but probably from one of the Turonian zones at Cuxton, Kent.

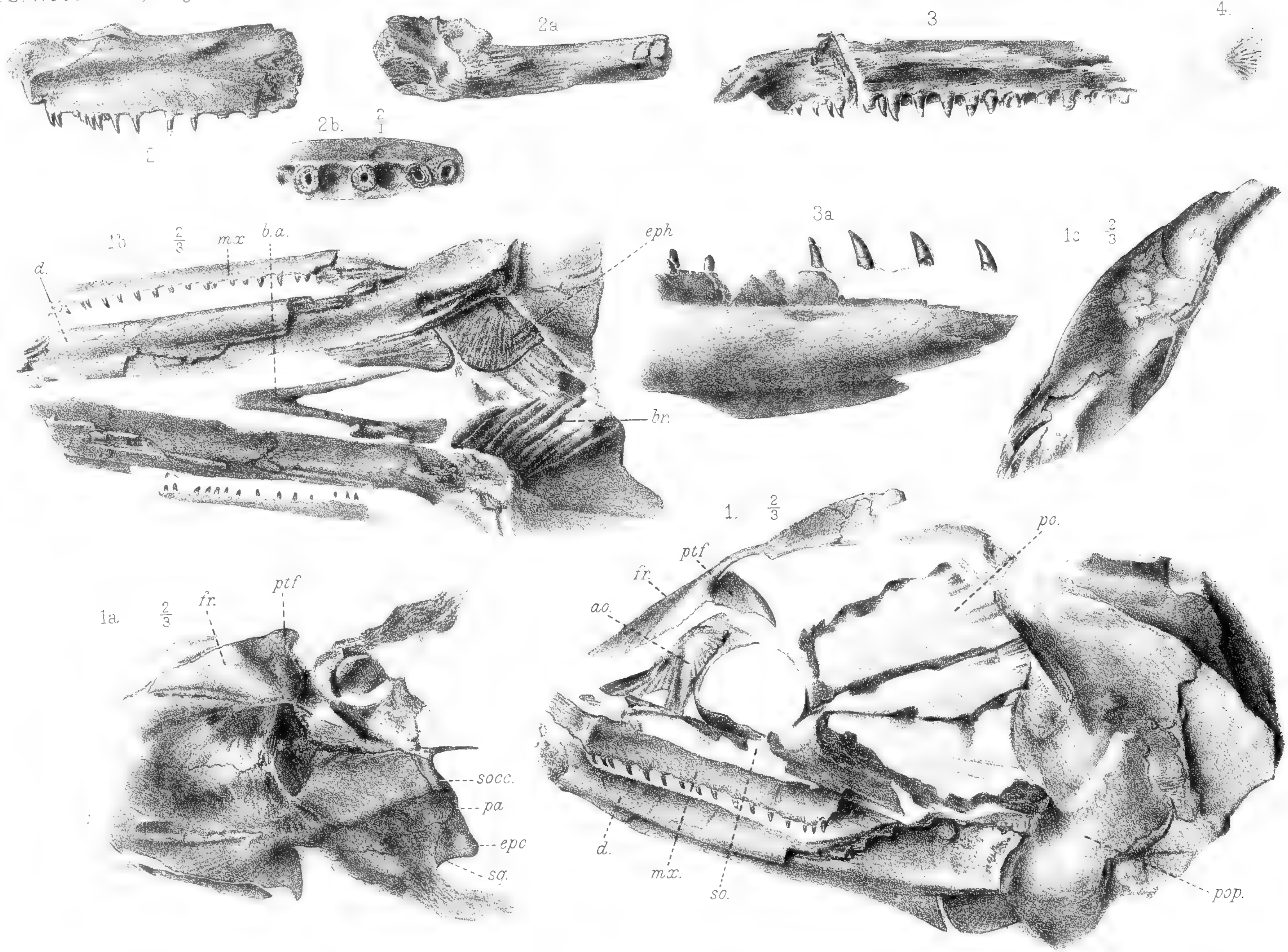
PLATE XXVII.

Fig.		Page.
1.	*Pachyrhizodus subulidens* (Owen); head from left side, (1 *a*) from above, and (1 *b*) from below, with (1 *c*) hinder view of right clavicle, two thirds nat. size.—Zone of *Schloenbachia varians;* Barton, Cambridge. Sedgwick Museum, Cambridge. *ao.*, antorbital; *ba.*, basibranchial; *br.*, branchiostegal rays; *d.*, dentary; *eph.*, epihyal; *epo.*, epiotic; *fr.*, frontal; *mx.*, maxilla; *pa.*, parietal; *po.*, postorbital; *pop.*, pre-operculum; *ptf.*, postfrontal (sphenotic); *so.*, suborbital; *socc.*, supraoccipital; *sq.*, squamosal.	129.
2.	Ditto; type specimen, anterior half of left maxilla, outer and (2 *a*) upper views, with (2 *b*) part of oral face enlarged twice.—Zone of *Holaster subglobosus;* Cherry Hinton, Cambridge. Sedgwick Museum, Cambridge.	129.
3.	Ditto; right maxilla, inner view, and (3 *a*) part of right dentary, outer view.—Zone of *Holaster subglobosus;* Sussex and (3 *a*) Halling, Kent. B. M. nos. P. 1808 and 36635.	130.
4.	Ditto; scale of B. M. no. P. 1808.	131.

Unless otherwise stated, figures are of the natural size.

Pl. XXVII.

A. S. Woodward, English Chalk Fishes.



A. H. Searle del. et lith.

West, Newman imp

Pachyrhizodus.

PLATE XXVIII.

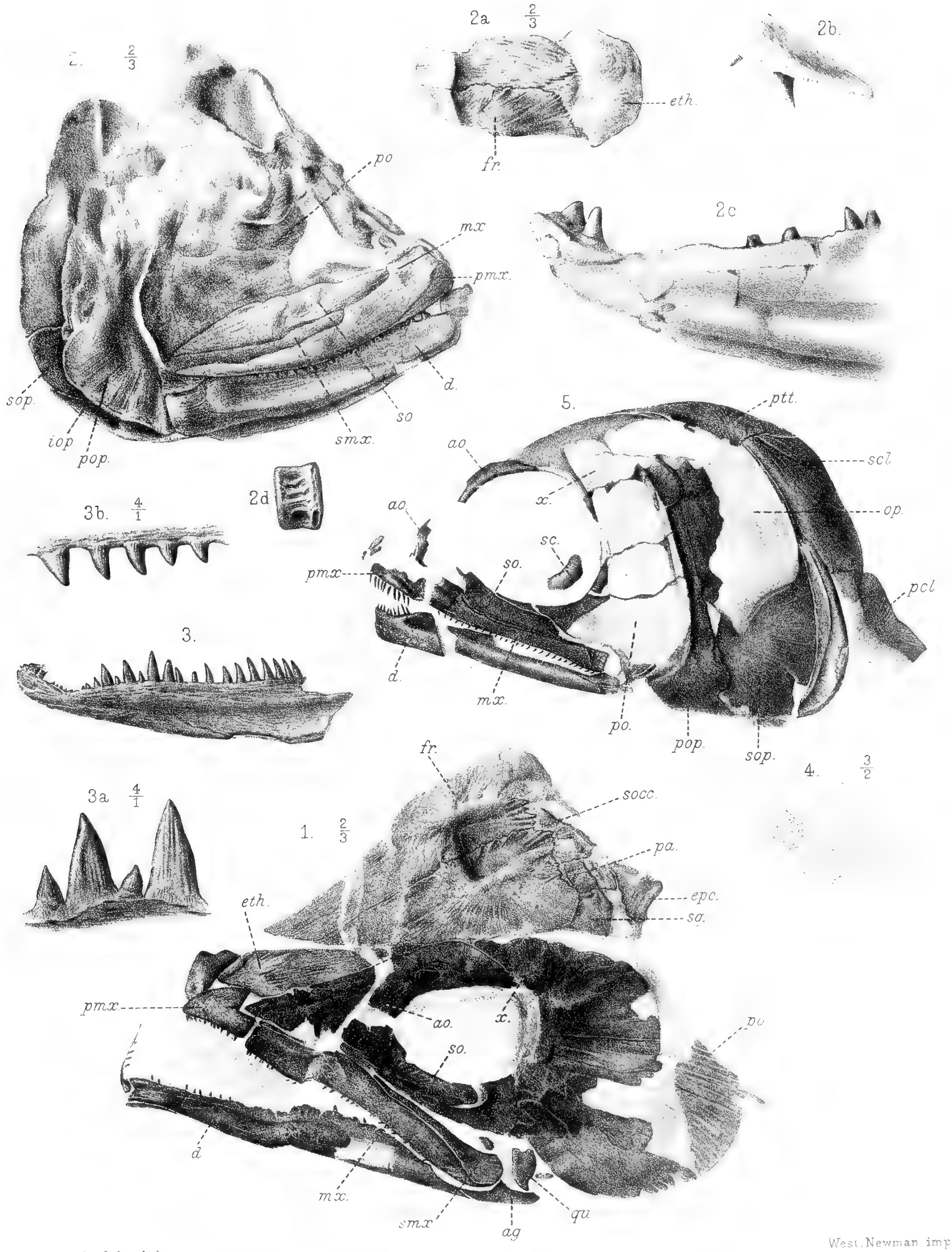
FIG. PAGE.

1. *Pachyrhizodus* (?) *magnus*, A. S. Woodward; head, distorted above, left side view, two thirds nat. size.—Probably zone of *Holaster subglobosus;* Hollingbourn, Kent. B. M. no. 37981. *ag.*, angular; *ao.*, antorbital; *d.*, dentary; *epo.*, epiotic; *eth.*, mesethmoid; *fr.*, frontal; *mx.*, maxilla; *pa.*, parietal; *pmx.*, premaxilla; *po.*, postorbital; *qu.*, quadrate; *smx.*, supramaxilla; *so.*, suborbital; *socc.*, supraoccipital; *sq.*, squamosal; *x.*, upper cheek-plate. 131.
2. *Elopopsis crassus* (Dixon); head in right side view and (2 *a*) upper view of snout, two thirds nat. size, with (2 *b*) left premaxilla, (2 *c*) part of left dentary, and (2 *d*) an anterior vertebral centrum, nat. size.—Probably zone of *Terebratulina gracilis;* Malling, near Lewes, Sussex. Willett Collection no. 61, Brighton Museum. *iop.*, interoperculum; *pop.*, preoperculum; *sop.*, suboperculum; other letters as in fig. 1. 134.
3. Ditto; left dentary, outer view, with (3 *a*) four lower teeth and (3 *b*) five maxillary teeth enlarged four times.—English Chalk. B. M. no. P. 10619. 135.
4. Ditto; imperfect scale, three halves nat. size.—Zone of *Rhynchonella cuvieri;* Wouldham, Kent. G. E. Dibley Collection (B. M. no. P. 10320). 135.
5. *Thrissopater megalops*, A. S. Woodward; head with pectoral arch, left side view.—Probably zone of *Holaster subglobosus;* near Lewes. Capron Collection (B. M. no. 49826). *op.*, operculum; *pcl.*, postclavicular plate; *ptt.*, post-temporal; *sc.*, sclerotic; *scl.*, supraclavicle; other letters as in figs. 1, 2. 137.

Unless otherwise stated, figures are of the natural size.

A. S. Woodward, English Chalk Fishes.

Pl. XXVIII.



A.H. Searle del et lith

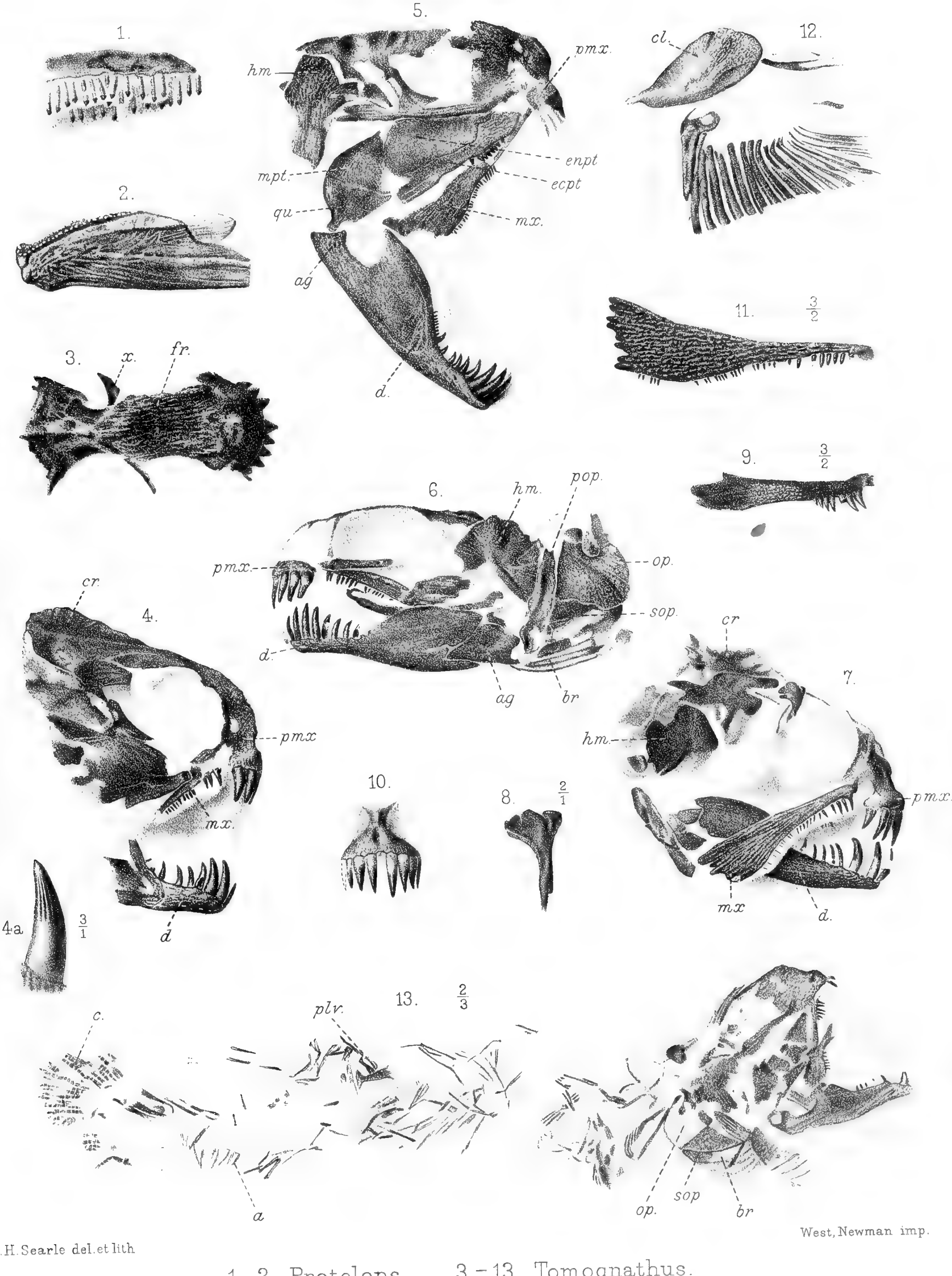
West, Newman imp.

1. Pachyrhizodus. 2-4. Elopopsis. 5. Thrissopater.

PLATE XXIX.

FIG.		PAGE.
1.	*Protelops anglicus*, A. S. Woodward; portion of upper jaw with cluster of teeth.—Zone of *Holaster subglobosus;* Glynde, Sussex. Capron Collection (B. M. no. 49906).	138.
2.	Ditto; anterior end of left dentary bone, showing bases of teeth.—Zone of *Holaster subglobosus;* Southeram, Lewes. Capron Collection (B. M. no. 49780).	138.
3.	*Tomognathus mordax*, Dixon; upper view of skull.—Zone of *Holaster subglobosus;* Burham, Kent. Brodie Collection (B. M. no. P. 7646). *fr.*, frontals; *x.*, a supraorbital bone.	140.
4.	Ditto; imperfect skull and mandible, right side view, with lower tooth (4 *a*) enlarged three times.—Zone of *Holaster subglobosus;* Southeram, Lewes. Capron Collection (B. M. no. 49762). *cr.*, supraoccipital crest; *d.*, dentary; *mx.*, maxilla; *pmx.*, premaxilla.	140.
5.	Ditto; imperfect skull and mandible, right side view.—English Chalk. B. M. no. P. 9237. *ag.*, angular; *ecpt.*, ectopterygoid; *enpt.*, entopterygoid; *hm.*, hyomandibular; *mpt*, metapterygoid; *qu.*, quadrate; other letters as in fig. 4.	140.
6.	Ditto; skull with opercular apparatus, left side view.—Probably zone of *Holaster subglobosus;* Burham. Bowerbank Collection (B. M. no. 39050). *br.*, branchiostegal rays; *op.*, operculum; *pop.*, preoperculum; *sop.*, suboperculum; other letters as in figs. 4, 5.	141.
7.	Ditto; imperfect skull and mandible, right side view.—English Chalk. B. M. no. P. 4844. Letters as in figs. 4, 5.	140.
8.	Ditto; a supraorbital bone, twice nat. size, specimen shown in fig. 7.	140.
9.	Ditto; left ectopterygoid, inner view, three halves nat. size.—Zone of *Holaster subglobosus;* Blue Bell Hill, Burham. S. J. Hawkins Collection (B. M. no. P. 9043).	140.
10.	Ditto; premaxillæ, front view, specimen shown in fig. 7.	140.
11.	Ditto; right maxilla, outer view, three halves nat. size.—Chalk; Kent. Enniskillen Collection (B. M. no. P. 3849).	140.
12.	Ditto; left clavicle (*cl.*) and base of pectoral fin.—Chalk; Kent. Egerton Collection (B. M. no. P. 1701).	141.
13.	Ditto; remains of head and trunk, right side view, two thirds nat. size.—Zone of *Holaster subglobosus;* Blue Bell Hill, Burham, Kent. Collection of G. E. Dibley, Esq., F.G.S. *a.*, anal fin-rays; *c.*, caudal fin-rays; *plv.*, basal bone of pelvic fin; other letters as in fig. 6.	141.

Unless otherwise stated, figures are of the natural size.



A. H. Searle del. et lith

West, Newman imp.

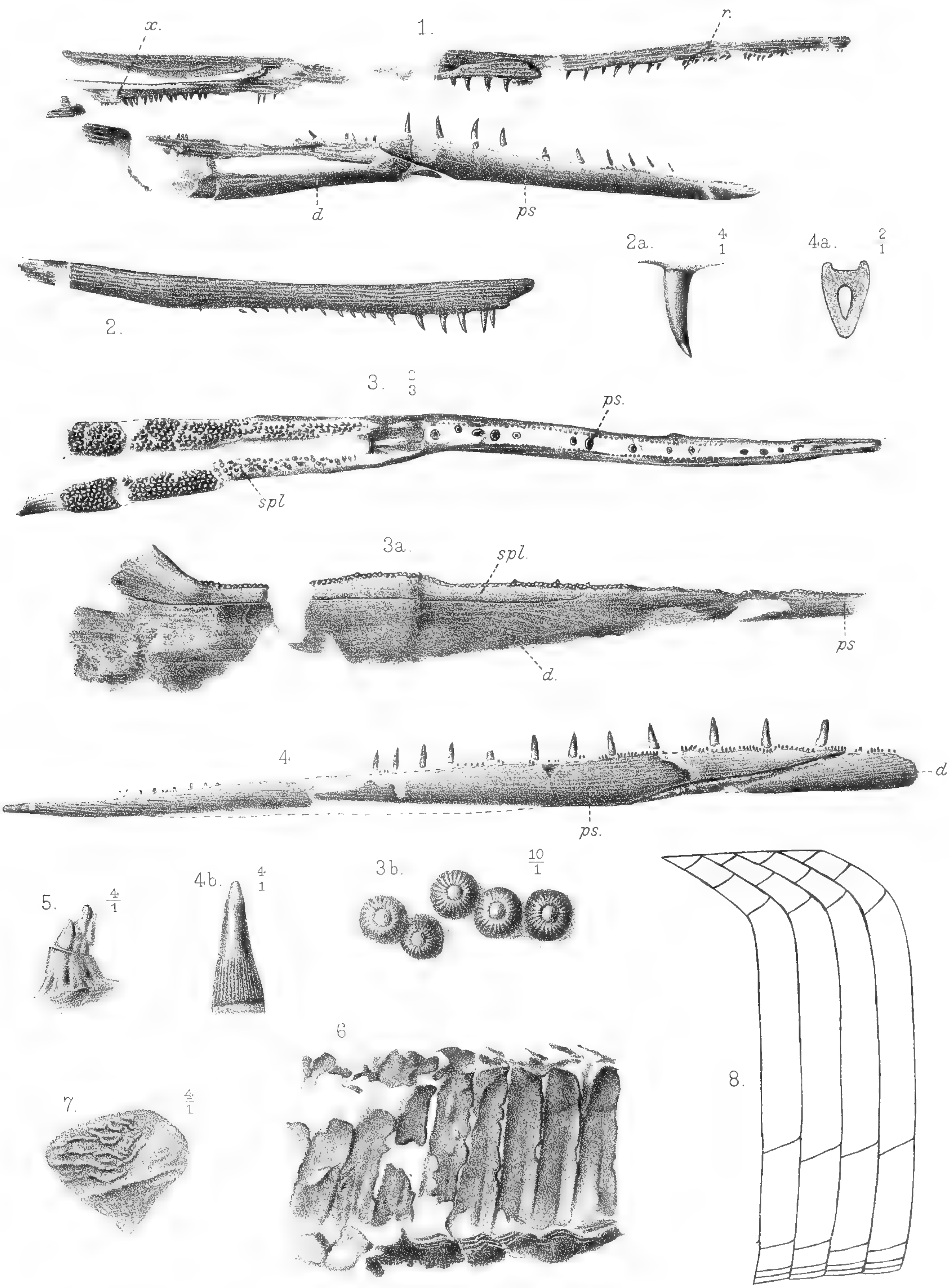
1, 2. Protelops. 3 - 13. Tomognathus.

PLATE XXX.

Fig.		Page.
1.	*Belonostomus cinctus*, Agassiz; portions of upper and lower jaws, right side view.—Zone of *Holaster subglobosus;* Dover, Kent. B. M. no. P. 8632. *d.*, dentary; *ps.*, presymphysial bone; *r.*, rostrum; *x.*, undetermined tooth-bearing bone.	143.
2.	Ditto; rostrum, left side view, with tooth (2 *a*) enlarged four times.—Turonian zone; Whyteleafe, Surrey. Miss Caroline Birley's Collection (B. M. no. P. 10521).	143.
3.	Ditto; mandible, wanting hinder end, upper view, two thirds nat. size, and (3 *a*) part of right side view, nat. size, with (3 *b*) some splenial teeth enlarged ten times.—Chalk; Brighton, Sussex. Willett Collection no. 91, Brighton Museum. *d.*, dentary; *ps.*, presymphysial bone; *spl.*, splenial.	144.
4.	Ditto; anterior portion of mandible, left side view, with (4 *a*) transverse section of presymphysial bone, twice nat. size, and (4 *b*) a median tooth, four times nat. size.—Ibid. Willett Collection no. 92, Brighton Museum. Letters as in fig. 3.	144.
5.	Ditto; broken base of lower median tooth, showing vertical fluting, four times nat. size.—English Chalk. B. M. no. P. 10448.	144.
6.	Ditto; scales of flank of the type specimen.—Turonian zone; Lewes, Sussex. Mantell Collection (B. M. no. 4266).	145.
7.	Ditto; dorsal scale, showing ornament, four times nat. size.—English Chalk. B. M. no. P. 10620.	145.
8.	Diagram of arrangement of flank-scales of *Belonostomus.*	

Unless otherwise stated, figures are of the natural size.

A. S. Woodward, English Chalk Fishes. Pl. XXX.



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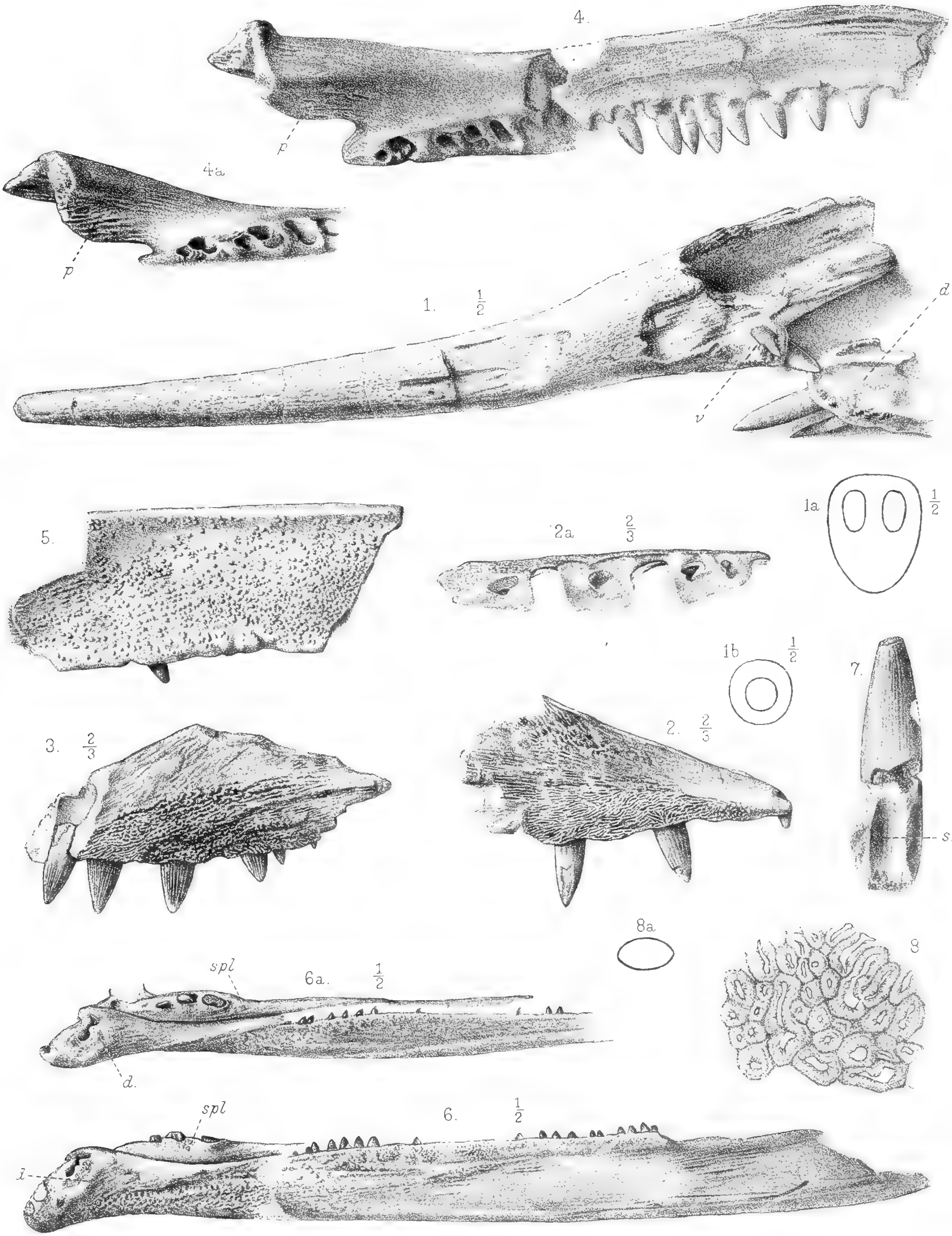
West, Newman imp.

Belonostomus.

PLATE XXXI.

Fig.		Page.
1.	*Protosphyræna ferox*, Leidy; rostrum, left side view, with inverted symphysial end of dentary beneath, one half nat. size; also (1 *a*, 1 *b*) two transverse sections of rostrum showing extent of internal cavity, one half nat. size.—Zone of *Holaster subglobosus;* Blue Bell Hill, Burham, Kent. S. J. Hawkins Collection (B. M. no. P. 6529). *d.*, dentary inverted; *v.*, vomer.	148.
2.	Ditto; right premaxilla, incomplete behind, outer and (2 *a*) lower views, two thirds nat. size.—Ibid. Mrs. Smith's Collection (B. M. no. 49012).	148.
3.	Ditto; left premaxilla, incomplete anteriorly, outer view, two thirds nat. size.—Ibid. Harford Collection (B. M. no. P. 5634).	148.
4.	Ditto; right maxilla, inner view, with (4 *a*) lower view of anterior end.—Ibid. Harford Collection (B. M. no. P. 5651 *a*). *p.*, antero-internal process.	149.
5.	Ditto; portion of large left maxilla, outer view.—Zone of *Holaster subglobosus;* Halling, Kent. Wetherell Collection (B. M. no. 43092).	149.
6.	Ditto; left mandibular ramus, incomplete behind, outer and (6 *a*) upper views, one half nat. size.—Chalk; Kent. Enniskillen Collection (B. M. no. P. 3955). *d.*, dentary; *spl.*, splenial.	149.
7.	Ditto; lower front tooth, inner view, showing hollow (*s.*) for successional tooth at base.—Zone of *Holaster subglobosus;* Blue Bell Hill, Burham. S. J. Hawkins Collection (B. M. no. P. 6530).	150.
8.	Ditto; transverse section of part of tooth, highly magnified, also (8*a*) outline of transverse section of tooth.	150.

Unless otherwise stated, figures are of the natural size.



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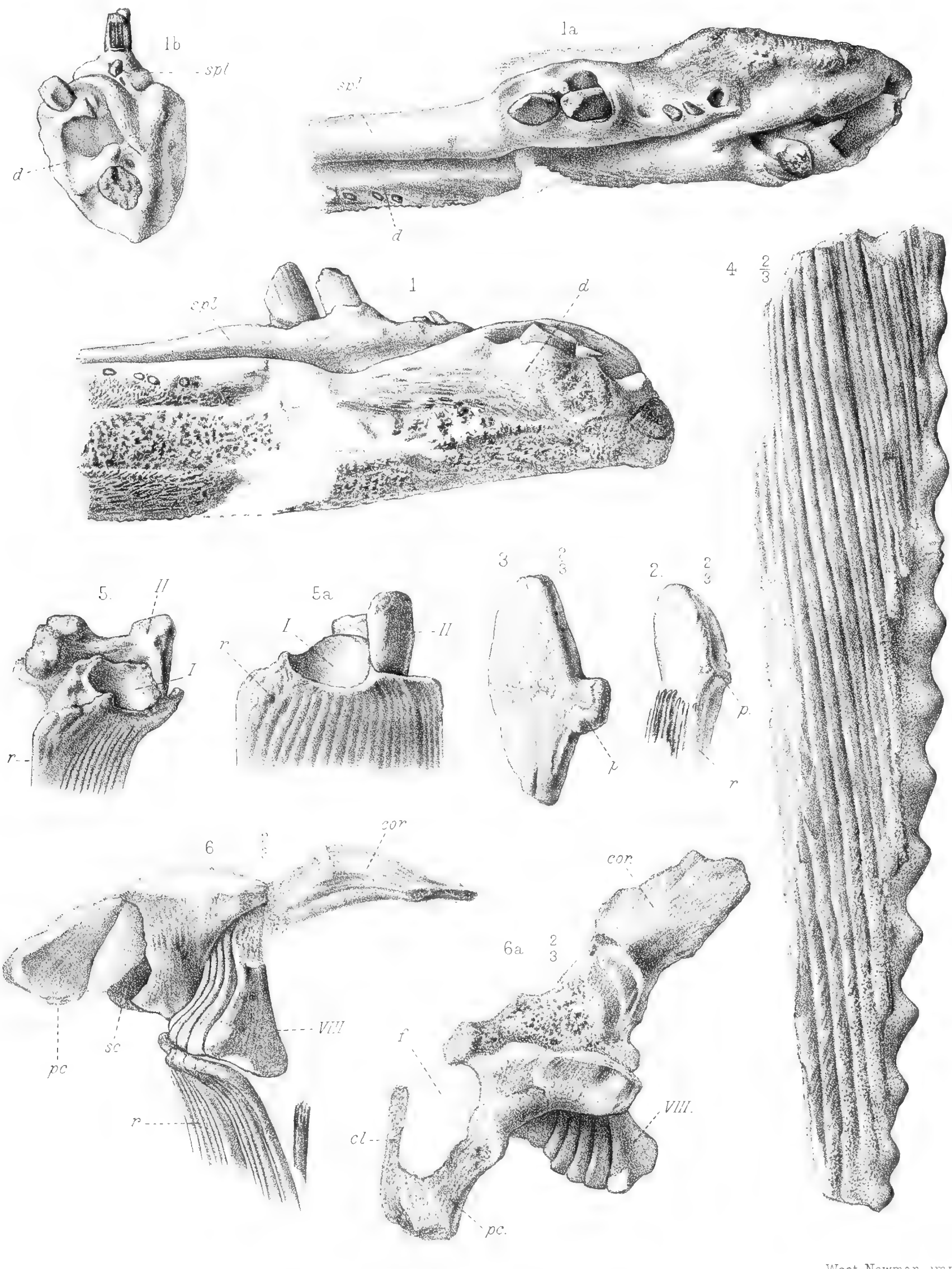
West, Newman imp

Protosphyræna.

PLATE XXXII.

Fig.		Page.
1.	*Protosphyræna ferox*, Leidy; anterior end of right mandibular ramus, outer, (1 *a*) upper, and (1 *b*) end views.—Chalk; Kent. Bowerbank Collection (B. M. no. 39438). *d.*, dentary; *spl.*, splenial.	149.
2.	*Protosphyræna* sp.; hypural bone, showing anterior process (*p.*) and a few overlapping fin-rays (*r.*), two thirds nat. size.—Chalk; Sussex. Egerton Collection (B. M. no. P. 1483).	150.
3.	Ditto; hypural bone, showing large anterior process (*p.*), two thirds nat. size.—Cambridge Greensand. B. M. no. 35160 *a*.	150.
4.	Ditto; portion of pectoral fin, two thirds nat. size.—Zone of *Holaster subglobosus;* Merstham, Surrey. B. M. no. 41079.	150.
5.	Ditto; preaxial portion of upper end of left pectoral fin, showing the rays (*r.*) clasping the first and second baseosts (I, II), anterior and (5 *a*) upper views.—Chalk; Kent. Toulmin Smith Collection (B. M. no. 41695).	150.
6.	Ditto; portion of left pectoral arch with base of fin, posterior and (6 *a*) inner views, two thirds nat. size.—English Chalk. B. M. no. P. 7573. *cl.*, clavicle; *cor.*, coracoid; *f.*, vacuity; *pc.*, pre-coracoid; *r.*, fin-rays; *sc.*, scapula; VIII, eighth baseost.	150.

Unless otherwise stated, figures are of the natural size.



A. H. Searle del. et lith. West, Newman imp.

Protosphyræna.

THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

VOLUME FOR 1908.

LONDON:

MDCCCCVIII.

TYPE SPECIMENS OF INFERIOR OOLITE AMMONITES.

THE type specimens of *Ammonites concavus*, *A. murchisonæ*, *A. striatulus*, and *A. jugosus*, originally described and figured by the Sowerbys in their 'Mineral Conchology,' have already been re-figured and discussed by Mr. S. S. Buckman in his 'Monograph of the Ammonites of the Inferior Oolite Series,' vol. i, published by the Palæontographical Society in parts between 1887 and 1907. The type specimens of the other species in the Sowerby Collection are now illustrated by new figures in the accompanying seven plates. It has been deemed useful to reprint the original descriptions for reference.

It has not been possible to trace the type specimens of *Ammonites braikenridgii*, *A. brongniarti*, *A. contractus*, and *A. gervillii*.

LIST OF PLATES.

Unless otherwise stated, the figures are of the natural size.

ILLUSTRATIONS

OF

TYPE SPECIMENS

OF

INFERIOR OOLITE AMMONITES

IN THE SOWERBY COLLECTION.

EDITED BY THE SECRETARY.

LONDON:
PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.
1908.

PRINTED BY ADLARD AND SON, LONDON AND DORKING.

The Palæontographical Society is indebted to Mr. S. S. Buckman, F.G.S., for assistance kindly rendered in the preparation of several of these Plates.

PLATE I.

Ammonites banksii, J. Sowerby, Min. Conch., vol. ii, p. 229, 1818, pl. cc.
[Brit. Mus. no. 43910.]

"*Specific Characters.*—Discoid, very thick; inner turns exposed; sides concave, largely tuberculated; front fluted, slightly convex; aperture transverse, almost three times as long as wide.

"A very bold formed shell; the narrow sides of the whorls are much relieved from each other, they are convex, and occupied by about 10 large obtuse tubercles: the great width of the convex margin, which is obtusely fluted, gives the whole a very massive appearance. There are about five turns, the last but one is in diameter equal to the thickness of the whole.

"In a valuable packet of fossils belonging to the Inferior Oolite, sent by some disinterested friend at present unknown to me, from the west of England, was the ponderous mass represented in this plate; it contains the ferruginous grains peculiar to that rock, with Belemnites, fragments of other shells, and also a piece of wood, changed almost into charcoal. I hope my friend will make himself known, and communicate the locality.

"I have indulged my feelings of esteem and friendship, by giving this magnificent Ammonite the name of that staunch supporter of science in general, and of natural history in particular, who has presided so long and so ably over the Royal Society."

[See also Pl. III, fig. 2.]

3/4 nat. size

F. H. Michael del. et lith. [illegible]

[illegible]

PLATE II.

Ammonites blagdeni, J. Sowerby, Min. Conch., vol. ii, p. 231, 1818, pl. cci.

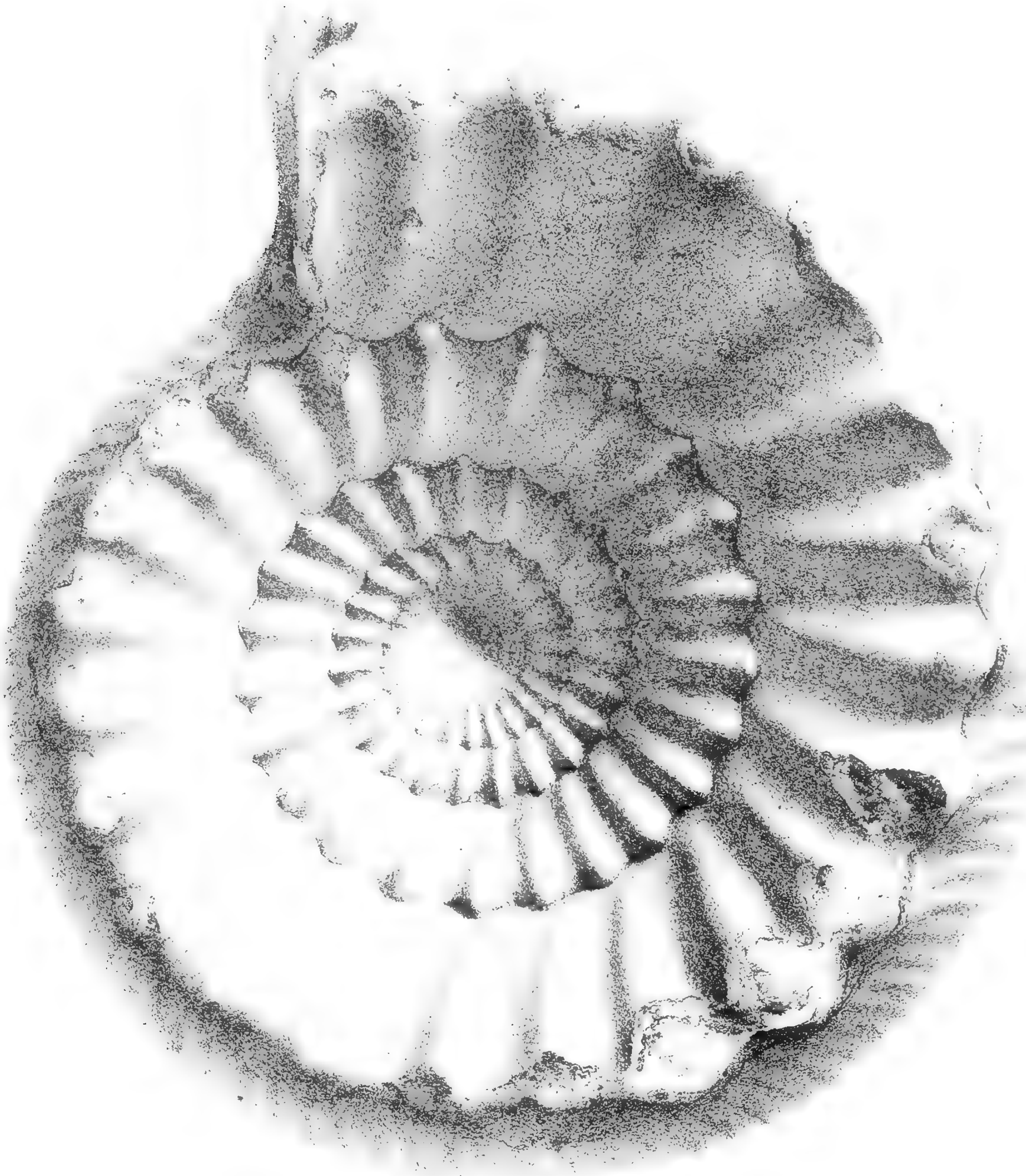
[Brit. Mus. no. 43908.]

"*Specific Characters.*—Subcylindrical, obtusely fluted, umbilicate; umbilicus reaching to the margin, conical, with large radii terminating upon the edge in a tubercle; aperture transverse, quadrangular, three times as wide as long.

"The umbilicus is deep; it occupies the whole side; the tubercles round its edges, about 22 in each turn, are obtuse in the cast of the inside, but where there are some remains of the outer surface they appear to be spiniform, there are four or five furrows on the front to each; the front is very slightly convex.

"A massive specimen from the lower Oolite, containing Belemnites, other Ammonites, etc.: it was given to me by my lamented friend, Dr. J. C. Lettsom. I have named it after the highly discerning, meritorious, yet most unassuming Sir Charles Blagden. The analogy between this and the preceding may remind conchologists of the long cordial friendship subsisting between Sir Charles and Sir Joseph Banks."

[See also Pl. III, fig. 1.]



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Ammonites blagdeni.

PLATE III.

Fig.

1. *Ammonites blagdeni*, J. Sowerby; front view of specimen, Brit. Mus. no. 43908.
2. *Ammonites banksii*, J. Sowerby; front view of specimen, Brit. Mus. no. 43910.

Side view, nat. size. Inner whorls, enlarged. Portion of outer whorl, enlarged.

Ammonites sowerbii, J. Sowerby, Min. Conch., vol. ii, p. 235, 1818, pl. ccxiii.

[Bristol Museum.]

"*Specific Characters.*—Discoid, carinated, with about eight spiniform tubercles upon each whorl; keel defined, entire; aperture elliptical. Var. β aperture circular, keel sometimes impressed.

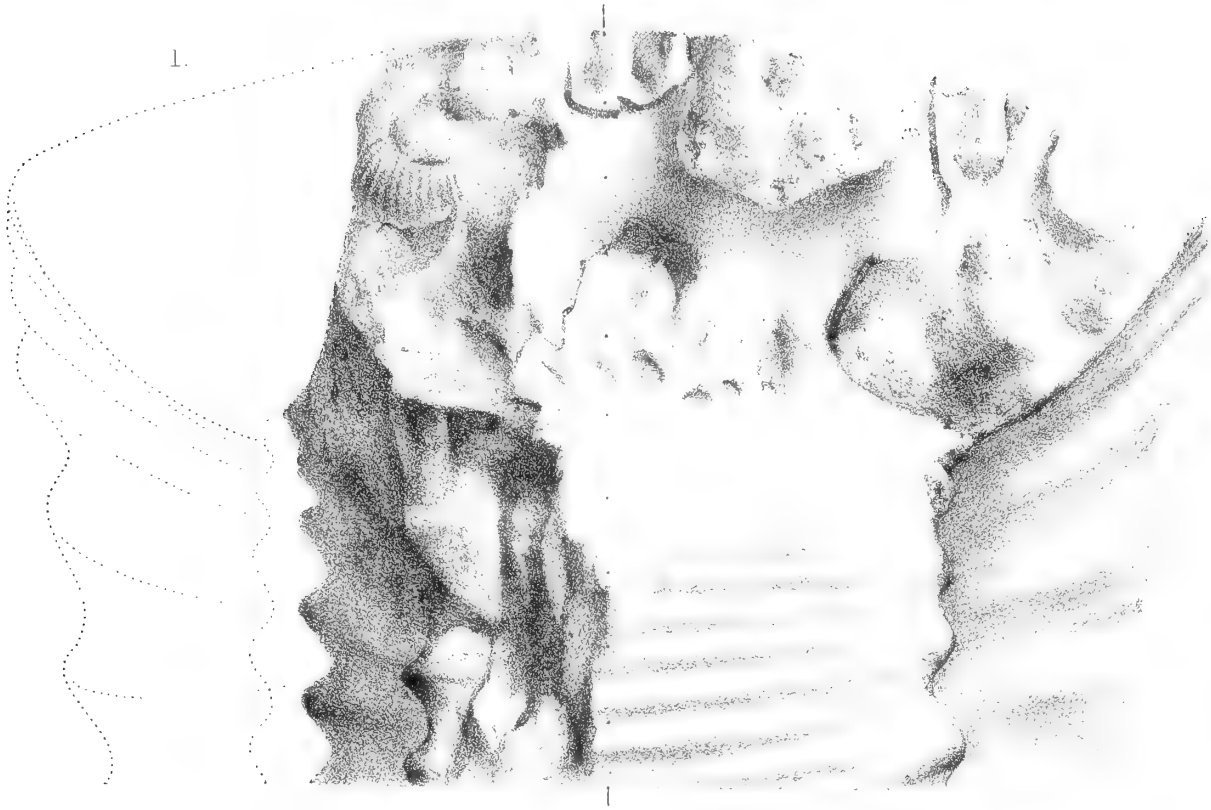
"Volutions about four, the inner ones concealed to the bases of the tubercles; the outer part of the volutions has many gentle undulations; the inner part is even, except that the base of each tubercle is extended towards the centre in an obtuse ridge. The keel nearly separated from the body of the shell; it is round and entire.

"In var. β the ridges from the bases of the tubercles are more prominent, and the keel sometimes so far sunk as to have a furrow on each side of it. The inner whorls of var. α appear to be more gibbose than the outer ones.

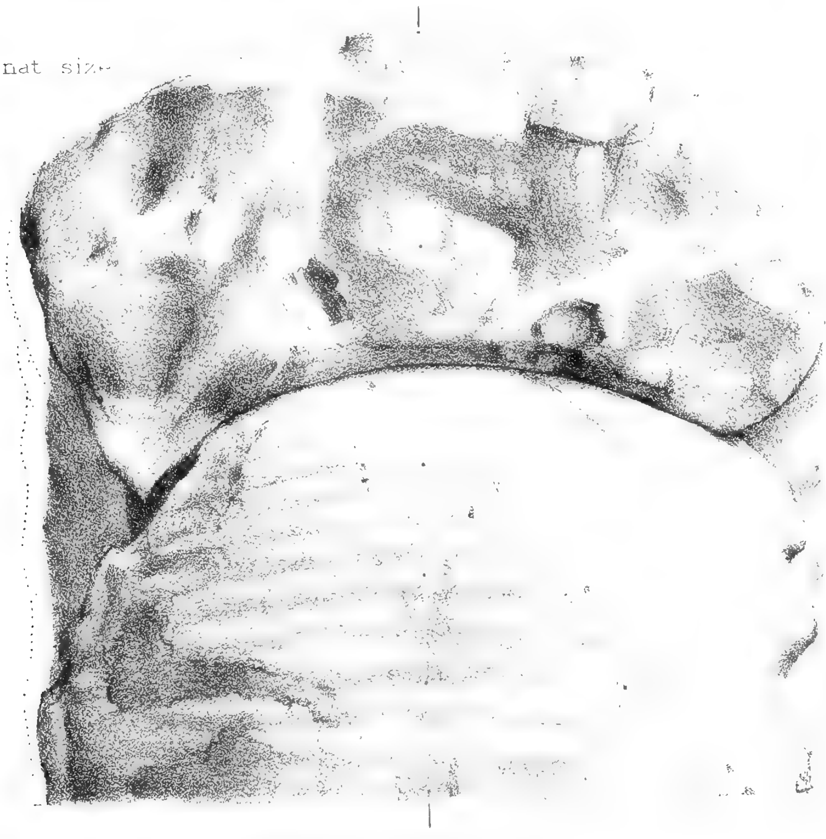
"Mr. Miller considers the shell figured as one of his rarest specimens; his collection has also to boast of several smaller specimens, belonging to var. β, which vary in the gibbosity of the whorls; they were all found at Dundry, in the Inferior Oolite."

Types, Inferior Oolite Ammonites　　　　　　　　　　　　　　　　　　　　　　　　　　　Pl. III

1.



2. $\frac{3}{4}$ nat. size.



F. H. Michael del et lith.　　　　　　　　　　　　　　　　　　　　　　　　　　　Bale & Danielsson, L^td imp.

1. Ammonites [illegible] 2. Ammonites [illegible]

PLATE IV.

Ammonites brocchii, J. Sowerby, Min. Conch., vol. ii, p. 233, 1818, pl. ccii.

[Brit. Mus. no. 43906.]

"*Specific Characters.*—Compressed; sides hollow, radiated; inner whorls half concealed; front circular, with many obtuse ridges; aperture lunate.

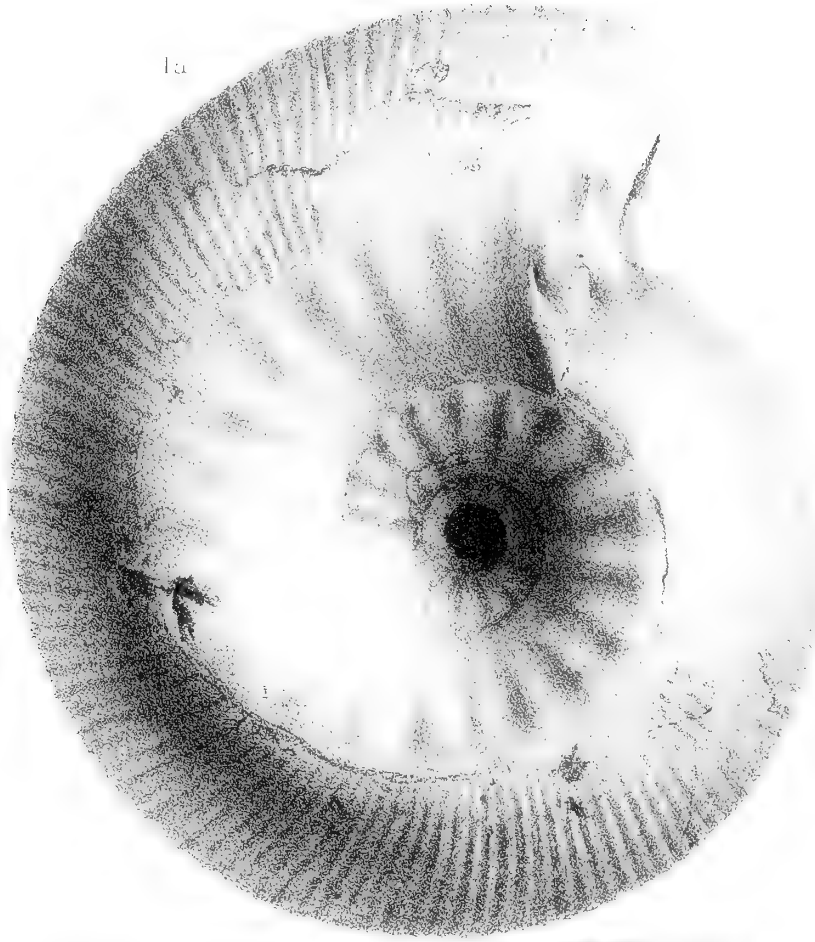
"Volutions three or four, very round; twenty radii extending nearly half over them; the rest of their surface is covered by nearly six times as many obtuse, arched, not very prominent ridges. Were the hollow sides considered as umbilicate, the umbilicus would be conical but would have no defined edge; the aperture is lunate, inclining to transversely elliptical. Thickness half the diameter. The septa are remarkably numerous, and finely sinuated.

"From the same friend, and probably from the same place, although of a greyer colour, as *A. banksii*, I received the large specimen; it seems to have been exposed to the weather.

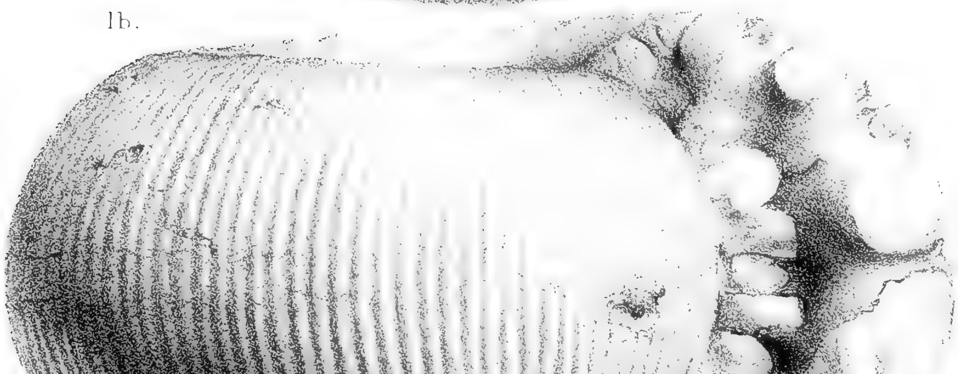
"The small specimen is from Dundry, by favour G. W. Braikenridge, Esq.

"The name is to commemorate the author of a recent valuable work upon the fossil shells of his own country."

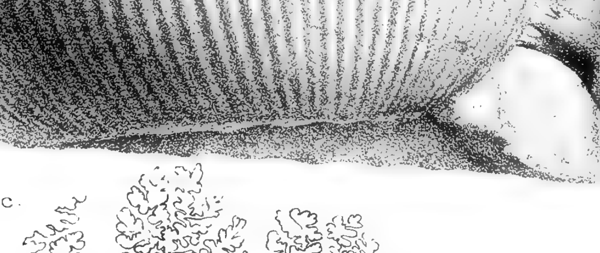
1a



1b.



1c.



F. H. Michael del. et lith.

Bale & Danielsson, Ltd imp.

Ammonites brocchii

PLATE V.

Fig.

1. *Ammonites brodiæi*, J. Sowerby, Min. Conch., vol. iv, p. 71, 1822, pl. ccclı. [Brit. Mus. no. 43905.]

"*Specific Characters.*—Largely umbilicate, gibbose, costated; costæ radiating, large and numerous, terminated upon the sides of the whorls by obtuse tubercles, front rounded, plicated; aperture transversely oblong, curved.

"Somewhat resembling *Ammonites brocchii*, tab. 202, but less gibbose and more strongly marked. The radiating ribs are slightly curved: from each of the tubercles that terminates them proceed about four plaits or lesser ribs, that pass around the front, and meet the tubercles upon the opposite side: this part of the inner volutions is concealed.

"This shell was given me a long while ago, as found on Portland Island, but with some doubt, by my kind and worthy friend, Jas. Brodie, Esq., whose name I wish to perpetuate: from the appearance of the stone I should rather suspect it to have come from the under or Ironshot Oolite."

[See also Pl. VII, fig. 3.]

Fig.

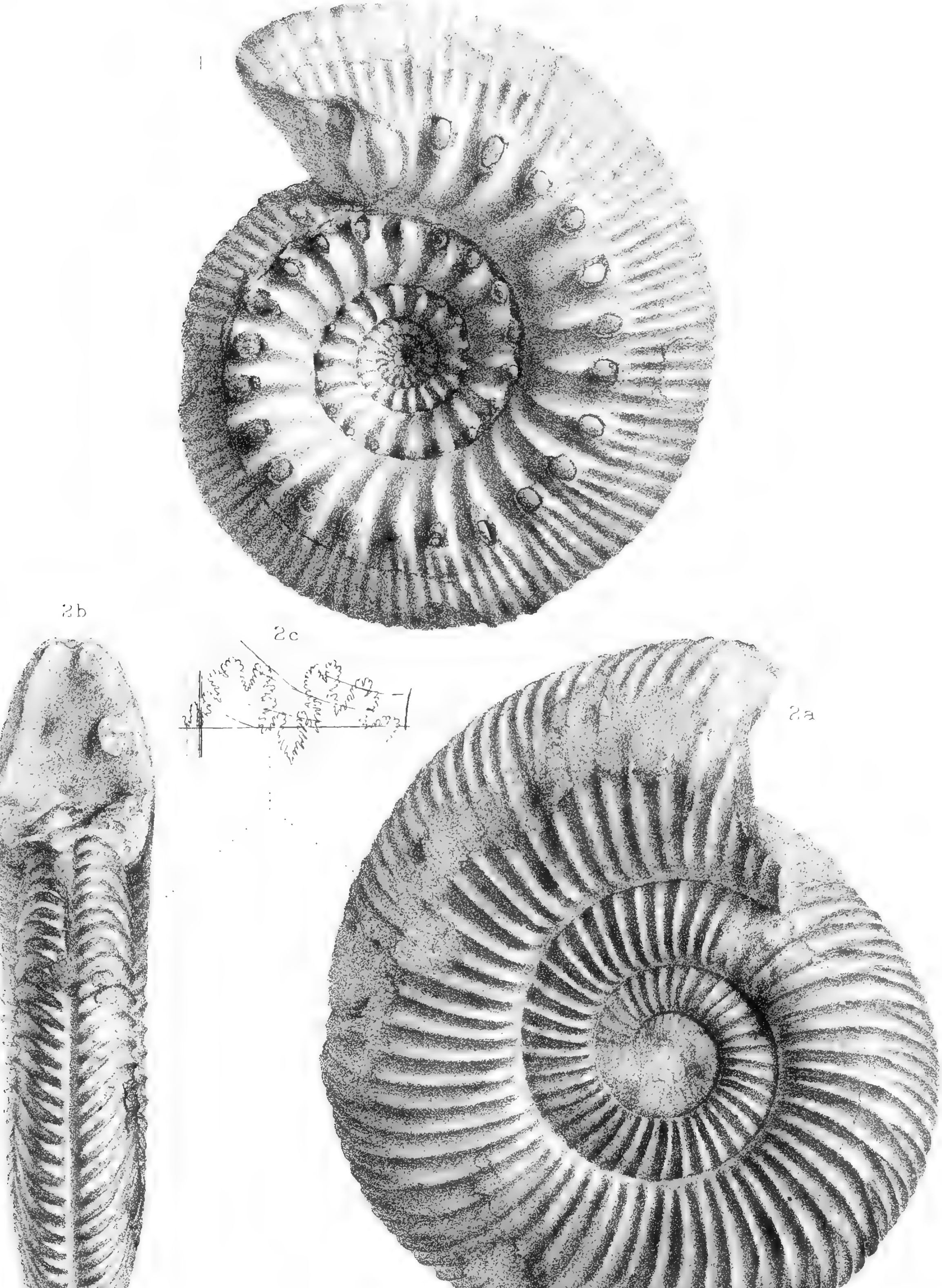
2. *Ammonites parkinsoni*, J. Sowerby, Min. Conch., vol. iv, p. 1, 1821, pl. cccvii. [Brit. Mus. no. 43925.]

"*Specific Characters.*—Discoid, with numerous highly elevated radii; whorls numerous, the inner ones exposed; radii slightly arched, bifid near the front which is very narrow and plain.

"Volutions numerous, with slightly convex sides and narrow edges: the arched radii are bent forward at their outer ends, and nearly meet at an acute angle upon the front, but do not pass over it: the edge of the shell is nearly flat, in the cast it is hollow in consequence of the removal of the siphuncle; the aperture is oblong, narrowest towards the front.

"This is the Ammonite so frequently split, polished, and sold at Bath: its outer surface is also often ground and polished, showing ramifying, sinuated, or simply undulated edges to the septa, according to the depth to which it has been worked. Misled by worked specimens that had lost the flat space in the middle of the edge, I have erroneously referred this species to the *Am. giganteus*, at page 55 of vol. i while speaking of such as are found near Keynsham, and those fine specimens given me by Dr. Lettsom, all of which are flatter than even the variety *a* of the *giganteus*, and have more whorls. The species before us occurs chiefly in Lyas, a stratum not known to contain any silicious deposit; it is consequently never imbedded in Chert or Flint, like the *A. giganteus* β. I suspect it also may be found in the lower beds of the Ironshot Oolite, as the specimen now figured is from near Yeovil, and contains vestiges of ferruginous grains. I am indebted to the kind attention of Dr. W. E. Leach for preserving it from the gothic hands of the mason, who is often as destructive of the essential characters of fossils, as some dealers still continue to be of the natural forms of recent shells, and who rob them without mercy of venerable coats that had resisted with various success the combined efforts of numerous sea-born enemies, whose ravages even leave marks more worthy of contemplation than the formal beauty betrayed by the file or polishing brush. . . .

"A section, showing the chambers filled partially with crystallised Carbonate of Lyme, is given at tab. 12 of British Mineralogy. It often extends to 18 inches or more in diameter, and when cut thin and viewed by transmitted light, offers a specious excuse for the unscientific mason."



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1. Ammonites brodiæi. 2. Ammonites parkinsoni.

PLATE VI.

FIGS.

1, 2. *Ammonites læviusculus,* J. de C. Sowerby, Min. Conch., vol. v, p. 73, 1824, pl. ccccli, figs. 1, 2.
[Brit. Mus. no. 43950 *a*, *b*.]

"*Specific Characters.*—Discoid, carinated, umbilicated, obscurely radiated; carina distinct; radii waved, alternately long and short, slightly elevated; umbilicus small, exposing parts of the inner whorls; aperture sagittate.

"One half of the diameter of the shell is occupied by the aperture, a third of the other half by the umbilicus, in full grown individuals; in young ones the umbilicus is larger. The front is obtuse with a large prominent keel in the middle of it; the sides are rather convex marked with waved, elevated radii, that are broader and less conspicuous on the outer whorls of the full grown shells. In young shells the aperture is oblong, rather square; as the shell grows older, the aperture becomes longer, more deeply notched by the preceding whorl, and narrower towards the front.

"Found in the inferior or Ironshot Oolite, at Dundry by G. W. Braikenridge, Esq., to whose liberality we are indebted for a series of specimens."

FIG.

3. *Ammonites subradiatus,* J. de C. Sowerby, Min. Conch., vol. v, p. 23, 1823, pl. ccccxxi, fig. 2.
[Brit. Mus. no. 43943.]

"*Specific Characters.*—Lenticular, umbilicated, carinated, and radiated; radii twice curved, ob[s]cure excepting near the margin, where they are bifid; umbilicus small; keel entire; aperture sagittate.

"The edge of this lenticular Ammonite is rather obtuse, and the carina not much relieved; the sides are nearly smooth, for the curved radii are very obscure excepting near the edge after they have become forked or divided, as some of them are, into three or even four short ribs; the thickness is about one fifth of the diameter.

"Found several years ago on the road from Bath to Bristol; it has been broken out of a mass of the Ironshot Oolite; no other specimen has reached our Cabinet."

FIG.

4. *Ammonites corrugatus,* J. de C. Sowerby, Min. Conch., vol. v, p. 74, 1824, pl. ccccli, fig. 3.
[Brit. Mus. no. 43951*a*.]

"*Specific Characters.*—Discoid, carinated and umbilicated, strongly radiated; carina distinct; radii waved, sometimes furcated, elevated; umbilicus broad, exposing parts of the inner whorls; aperture obovate; front obtuse.

"Resembling the last [*Ammonites læviusculus*], but thicker, with more prominent radii, and a broader front.

"From Dundry, with the *A. læviusculus.*"

FIG.

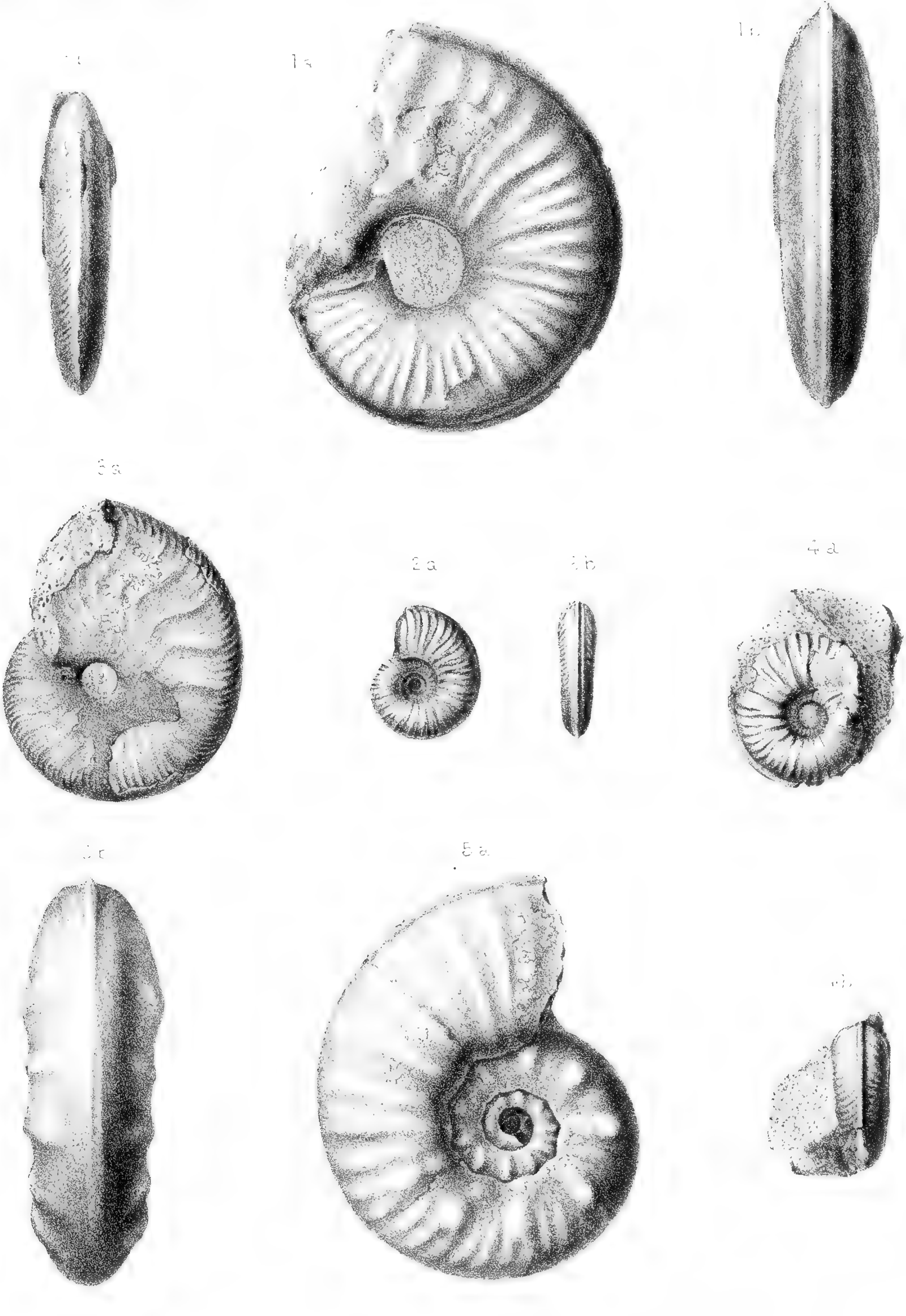
5. *Ammonites browni,* J. Sowerby, Min. Conch., vol. iii, p. 114, 1820, pl. cclxiii, figs. 4, 5.
[Brit. Mus. no. 43966.]

"*Specific Characters.*—Discoid, with radiating undulations; inner whorls half exposed, with large tubercles upon each side; marginal undulations many, central ones few, rising into tubercles; front rounded with a distinct keel; aperture cordate.

"In general appearance very much like the last [*Ammonites koenigi*], but rather thicker and sufficiently distinguished by the keel and knobs upon the inner volutions.

"From Dundry, by favour of my good friend G. W. Braikenridge, Esq. I wish by the name of this Ammonite to commemorate R. Brown, Esq., a gentleman of general knowledge and an excellent botanist."

Types, Inferior Oolite Ammonites — Pl. VI



[illegible]

, 2. Ammonites [illegible] — 3. Ammonites [illegible]

4. Ammonites [illegible] — 5. Ammonites [illegible]

PLATE VII.

FIGS.

1, 2. *Ammonites humphriesianus*, J. de C. Sowerby, Min. Conch., vol. v, p. 161, 1825, Pl. D, fig. 1. [Brit. Mus. nos. 43908 *a*, *b*.]

"*Specific Characters.*—Discoid, thick, radiated, inner whorls exposed; front rounded, radii large, numerous, rising into a tubercle on each side of the whorl, where they branch into three; aperture arched, oblong.

"Composed of about four or five whorls, which are almost wholly exposed, more especially the outer ones; the radii are straight, gradually rising towards a conical tubercle, which in the outer whorls occupies about the middle of each side, and is distant from the suture, but in the inner ones is placed close to the suture that separates the turns; the inner whorls have a much flatter front than the outer, whence their sections are quadrangular, whilst the aperture of a large shell is almost lunate.

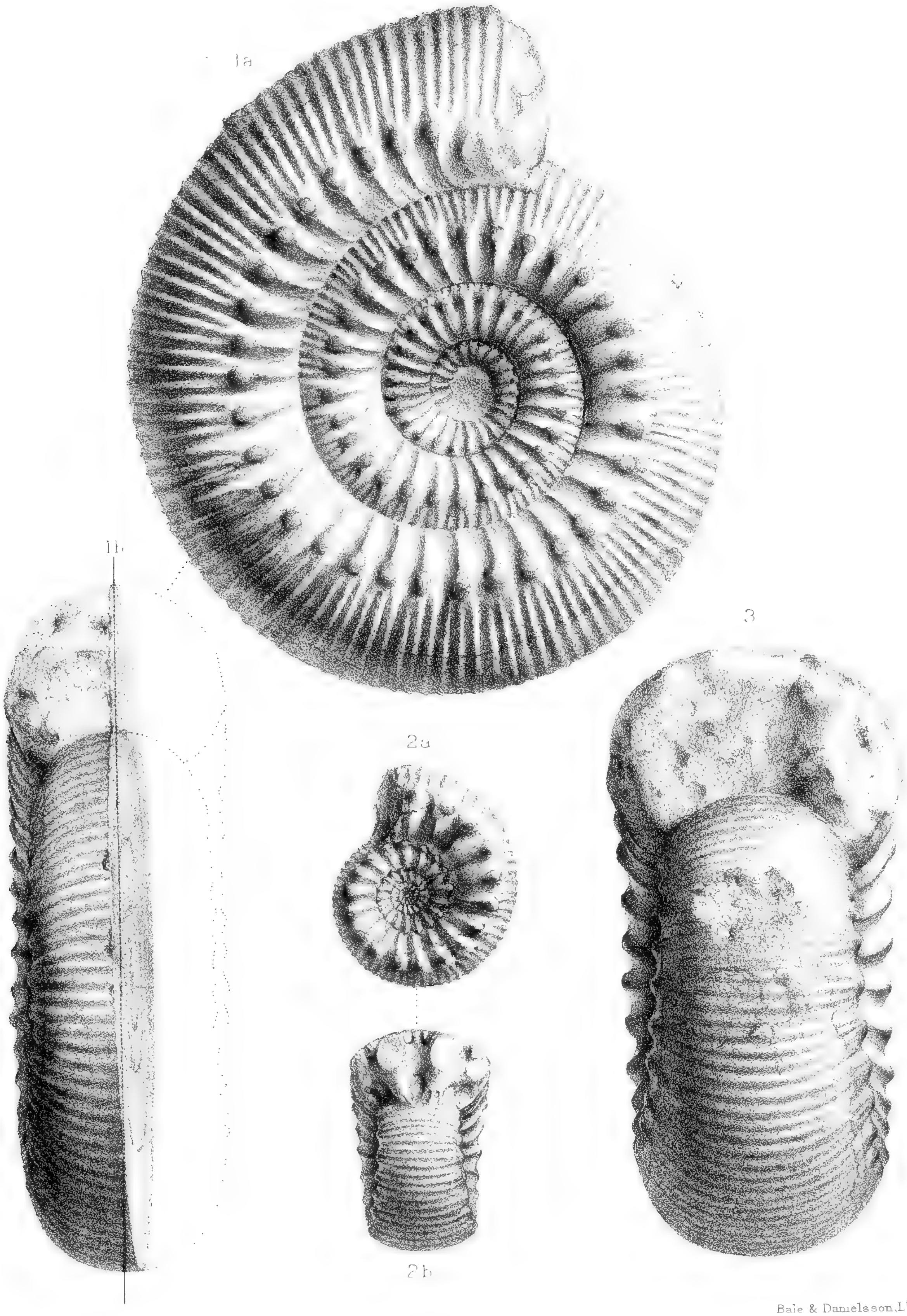
"The two specimens figured of this Ammonite are from the stock of Mr. George Humphries. They were marked *Sherborne*, and appear to come from the Ironshot or Inferior Oolite: the larger one is only a polished half. The same species occurs abundantly at Bayeux in Normandy of a brighter colour."

FIG.

3. *Ammonites brodiæi*, J. Sowerby; front view of specimen. Brit. Mus. no. 43905.

Types, Inferior Oolite Ammonites

Pl. VII.



F. H. Michael del. et lith.

Bale & Danielsson, L^td imp.

1, 2. Ammonites humphresianus. 3. Ammonites brodiæi.

Palæontographical Society, 1908.

A MONOGRAPH

OF THE

CRETACEOUS LAMELLIBRANCHIA

OF

ENGLAND.

BY

HENRY WOODS, M.A.

UNIVERSITY LECTURER IN PALÆOZOOLOGY, CAMBRIDGE.

VOL. II. PART V.

VENERIDÆ, CARDIIDÆ, DICERATIDÆ, MONOPLEURIDÆ, AND CORBULIDÆ.

Pages 181—216; Plates XXVIII—XXXIV.

LONDON:

PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.

1908.

PRINTED BY ADLARD AND SON, LONDON AND DORKING.

Genus—Dosiniopsis, *T. A. Conrad*, 1864.

('Proc. Acad. Nat. Sci. Philadelphia,' p. 213.)

Dosiniopsis subrotunda (*Sowerby*), 1836. Plate XXVIII, figs. 1—6.

1836.	Cytheræa subrotunda,	*J. de C. Sowerby.*	Trans. Geol. Soc., ser. 2, vol. iv, pp. 240, 341, pl. xvii, fig. 2.
1850.	Venus —	*A. d'Orbigny.*	Prodr. de Pal., vol. ii, p. 159.
1854.	Cytherea —	*J. Morris.*	Cat. Brit. Foss., ed. 2, p. 201.
1870.	Venus —	*F. Stoliczka.*	Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 161 (*Caryatis*).

Description.—Shell rather thick, rounded, oval or somewhat orbicular, of small or moderate convexity; length rather greater than height; moderately, sometimes considerably, inequilateral. Antero-dorsal margin long, concave. Anterior margin rounded, passing gradually into the considerably curved ventral margin. Postero-dorsal margin very long, convex, with a considerable ventral slope. Posterior margin rounded. Umbones small, pointed, close together, slightly curved anteriorly. Lunule elongate, depressed, distinctly limited. Escutcheon narrow, depressed, with a sharp border. Pallial sinus rather large, sub-angular. Ornamentation consists of fine concentric striæ, and growth-lines.

Hinge: In the right valve three strong, nearly straight, diverging cardinal teeth, of which the anterior and median are closer together and diverge at a smaller angle than the median and posterior, the last being divided by a shallow longitudinal groove; there is a small posterior lateral tooth and an elongate anterior pit. In the left valve the anterior of the three diverging cardinal teeth is nearly vertical, the median is the stoutest, and the posterior is oblique and slender; the anterior lateral tooth is elongate and parallel to the lunular margin; the posterior lateral is very small.

Measurements:

	(1)	(2)	(3)	(4)	(5)	
Length .	34 .	31 .	29 .	28 .	26	mm.
Height .	32 .	28 .	26·5 .	26 .	23·5	„

(1—5) Blackdown.

Type.—From Blackdown; in the Bristol Museum.

Distribution.—Upper Greensand (zone of *Schlœnbachia rostrata*) of Blackdown.

DOSINIOPSIS CAPERATA (*Sowerby*), 1826. Plate XXVIII, figs. 7—10.

1826.	VENUS CAPERATA,	*J. de C. Sowerby.*	Min. Conch., vol. vi, p. 31, pl. dxviii, figs. 1 3.
1850.	— —	*A. d'Orbigny.*	Prodr. de Pal , vol. ii, p. 159.
1854.	CYTHEREA —	*J. Morris.*	Cat. Brit. Foss., ed. 2, p. 200.
1865.	VENUS CAPERATA,	*F. J. Pictet and G. Campiche.*	Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 189.
1868.	— —	*A. Briart and F. L. Cornet.*	Meule de Bracquegnies (Mém. cour. et Mém. des Sav. étrangers, vol. xxxiv), p. 74, pl. vii, figs. 6—8.
1870.	— —	*F. Stoliczka.*	Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 160 (*Caryatis*).
? Non 1845.	— —	*A. d'Orbigny.*	Pal. Franç Terr. Crét., vol. iii, p. 445, pl. ccclxxxv, figs. 9, 10 (*V. uniformis*, Prodr. de Pal., vol. ii, p. 236).

Description.—Shell oval, convex, moderately or considerably inequilateral; length rather greater than height. Antero-dorsal margin concave. Anterior margin rounded, passing gradually into the convex ventral margin. Posterior less convex than the anterior margin, sometimes subtruncate. Postero-dorsal margin long, slightly convex. Umbones prominent, curved anteriorly. Lunule ovate. Pallial sinus rather large, sub-angular. Ornamentation consists of strong, regular, concentric ribs.

Hinge: In the right valve three stout cardinals separated dorsally, the anterior and median being close together and nearly vertical, the posterior oblique and divided by a longitudinal groove; there is an anterior elongate pit and a strong posterior lateral tooth. In the left valve the median is the stoutest of the three cardinals and is sometimes joined dorsally to the nearly vertical anterior cardinal; the posterior cardinal is slender and very oblique; the anterior lateral is strong, elongate and parallel to the lunular margin.

Measurements:

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Length	34	31	30	28	26	25	21	15 mm.
Height	30·5	29	26	24·5	22	23	18·5	14 ,,

(1—8) Blackdown.

Remarks.—Internal casts from the Folkestone Beds of Pulborough were referred to this species by Forbes. I have not seen any specimens which would enable me to record the occurrence of *D. caperata* in the Lower Greensand.

Type.—From Blackdown; in the British Museum.

Distribution.—Upper Greensand (zone of *Schlœnbachia rostrata*) of Blackdown and Haldon. Recorded by Barrois from the Upper Greensand of Lulworth, and by Jukes-Browne from the Upper Greensand of the Isle of Wight.

Genus—Cyprimeria, *T. A. Conrad*, 1864.

('Proc. Acad. Nat. Sci. Philad.,' 1864, p. 212, and 'Amer. Journ. Conch.,' vol. ii, 1866, p. 102. Stoliczka, 'Palæont. Indica, Cret. Fauna S. India,' 1870, p. 157.)[1]

Sub-genus—Cyclorisma, *W. H. Dall*, 1903.

('Proc. U.S. Nat. Mus.,' vol. xxvi, 1903, p. 357. Syn. *Cyclothyris*, T. A. Conrad in W. C. Kerr's 'Geol. Rep. N. Carolina,' vol. i, Appendix 1 (1875), p. 8. Non *Cyclothyris*, M'Coy, 1844.)

Cyprimeria (Cyclorisma) vectensis (*Forbes*), 1845. Plate XXVIII, figs. 11—18.

1845.	Venus vectensis,	*E. Forbes.*	Quart. Journ. Geol. Soc., vol. i, p. 240, pl. ii, fig. 4.
1850.	— —	*A. d'Orbigny.*	Prodr. de Pal., vol. ii, p. 118.
1854.	— —	*J. Morris.*	Cat. Brit. Foss., ed. 2, p. 231.
1865.	— —	*F. J. Pictet and G. Campiche.*	Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 188.
1870.	— —	*F. Stoliczka.*	Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 160.
? 1883.	— —	*W. Keeping.*	Foss., etc. Neoc. Upware and Brickhill, p. 125.

Description.—Shell oval, or nearly orbicular, a little longer than high, regularly convex, slightly or moderately inequilateral. Margin rounded. Umbones small, pointed, somewhat curved forwards. Lunule indistinct, not impressed, limited by a faint line. Pallial sinus angular, directed upwards. Margins of valves smooth. Surface of shell smooth except for small, inconspicuous, concentric ridges, and occasional growth-rings.

Hinge: In the right valve an anterior and a median cardinal and two posterior laminar teeth (which together represent the posterior cardinal) diverge from under the umbo; the anterior is directed forwards, the median is nearly vertical,

[1] The following European species are referred by Conrad and by Stoliczka to the genus *Cyprimeria*: *Cyclina primæva*, Zitt., *Dosinia cretacea*, Zitt., *Circe discus* (Math.), *Circe concentrica*, Zitt., and *Arcopagia rotundata*, d'Orb. Holzapfel figures *Cyprimeria Geinitzi* (Müll.) and *C. moneta*, Holz., from the Aachen Greensand.

and the two posterior slope obliquely backwards. In the left valve a long, oblique laminar, posterior cardinal; a median cardinal (which is divided); and an anterior cardinal, diverge under the umbo, from which they are separated by a narrow space or channel. In front of the anterior cardinal the anterior part of the hinge-plate is concave.

Measurements :

	(1)	(2)	(3)	(4)	(5)	
Length .	38 .	32 .	31 .	28 .	24	mm.
Height .	34 .	29·5 .	29 .	26 .	22·5	,,

(1—5) Crackers, Atherfield.

Affinities.—This species shows some resemblance to *Venus vendoperana* (Leymerie), especially to the example figured by Pictet and Renevier,[1] but the umbones are less prominent and the lunule is less distinct.

Type.—The type came from the Crackers of Atherfield, but cannot now be found.

Distribution.—Lower Greensand (Crackers) of Atherfield. Recorded from the Atherfield Clay and Bed vii of Atherfield by Fitton. Recorded by Topley from the Atherfield Beds of Peasmarsh and Shalford.[2]

Cyprimeria (Cyclorisma) parva (*Sowerby*), 1826. Plate XXVIII, figs. 19—23; Plate XXIX, figs. 1—3.

1826. Venus parva, *J. de C. Sowerby.* Min. Conch., vol. vi, p. 32, pl. dxviii, figs. 4—6.

1845. Lucina ? solidula, *E. Forbes.* Quart. Journ. Geol. Soc., vol. i, p. 239, pl. ii, fig. 7.

1850. Venus parva, *A. d'Orbigny.* Prodr. de Pal., vol. ii, p. 159 (not Blackdown).

— Lucina solidula, *d'Orbigny.* Ibid., vol. ii, p. 118.

1854. Cytherea parva, *J. Morris.* Cat. Brit. Foss., ed. 2, p. 201 (*partim*).

Lucina solidula, *Morris* Ibid., ed. 2, p. 208.

1865. Venus parva, *F. J. Pictet and G. Campiche.* Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 188.

1870. — — *F. Stoliczka.* Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 160 (*Caryatis*).

— Lucina ? solidula (? Mysia), *Stoliczka.* Ibid., vol. iii, pp. 252, 262.

? 1895. Venus *cf.* parva, *E. Tiessen.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xlvii, p. 484.

[1] Pictet and Renevier, 'Foss. Terr. Aptien' ('Matér. Pal. Suisse,' ser. 1, 1855–56), p. 71, pl. vii, fig. 9. Pictet and Campiche, 'Terr. Crét. Ste. Croix' ('Matér. Pal. Suisse,' ser. 4, 1865), p. 181, pl. cxi, fig. 12.

[2] I have not seen the specimen recorded by Keeping from Upware.

Non 1840. VENUS PARVA, *A. Goldfuss.* Petref. Germ., vol. ii, p. 246, pl. cli, fig. 4 (*V. Goldfussi*, Geinitz, 1850; *V. subparva*, d'Orbigny, 1850).

— 1841. — — *F. A. Römer.* Die Verstein. d. nord-deutsch. Kreidegeb., p. 72 (*Venus subinflexa*, Römer, 1836).

— 1846. — — *A. E. Reuss.* Die Verstein. der böhm. Kreideformat., pt. 2, p. 20, pl. xli, figs. 16, 17.

— 1863. — — *A. v. Strombeck.* Zeitschr. der deutsch. geol. Gesellsch., vol. xv, p. 146.

— 1868. — — *A. Briart and F. L. Cornet.* Meule de Bracquegnies (Mém. cour. et Mém. des Sav. étrangers, vol. xxxiv), p. 75, pl. viii, figs. 1, 2.

— 1877. CYTHEREA PARVA, *G. Böhm.* Zeitschr. der deutsch. geol. Gesellsch., vol. xxix, p. 241.

— 1883. VENUS *cf.* PARVA, *A. Fritsch.* Stud. im Gebiete der böhm. Kreideformat., iii, Iserschicht., p. 109, fig. 77.

— 1885. VENUS PARVA, *F. Nötling.* Die Fauna d. baltisch. Cenoman. (Palæont. Abhandl., vol. ii), p. 32, pl. v, fig. 11.

— 1893. — — *Fritsch.* Op. cit., v, Priesen. Schicht., p. 98, fig. 118.

Description.—Shell small, oval, convex, moderately inequilateral. Antero-dorsal margin slightly concave, or nearly straight, forming a rounded angle with the anterior margin which curves rapidly to join the convex ventral margin. Posterior margin rounded or subtruncate. Postero-dorsal margin slightly convex. Umbones rather prominent, curved inwards and forwards. Lunule broad, ovate, more or less projecting, limited by a groove. Pallial sinus large, angular. Ornamentation consists of small, somewhat irregular, concentric ribs, and occasional growth-rings.

Hinge: In the right valve the anterior and median cardinals are stout and nearly parallel, and the two posterior teeth (which represent the posterior cardinal) are oblique and diverging; in front of the anterior cardinal is a groove, bounded by a ridge above and below, parallel to the inner margin of the hinge-plate. In the left valve the anterior and median cardinal teeth diverge widely under the umbo and the posterior cardinal is oblique; the anterior cardinal is continued forward into a ridge along the inner margin of the hinge-plate.

Measurements :

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
Length	20·5	21	20	20	19	16	14	10	mm.
Height	17	17·5	17·5	17	16	14	12	8·5	,,

(1) *Perna*-bed, East Shalford.

(2—8) Crackers, Atherfield.

Affinities.—The differences between this species and *C.* (*Cyclorisma*) *rotomagensis* are given below.

The form from Bracquegnies, which was referred to *Venus parva* by Briart and Cornet, is less elongate.

The hinge differs from that of other species of *Cyclorisma* in that the anterior tooth in the left valve is continued forwards into a ridge at the inner margin of the hinge-plate.

Lucina ? solidula, Forbes, appears to be identical with *Venus parva*, Sowerby; the type is missing, but other specimens which are in the Museum of the Geological Society and were probably identified by Forbes, are undoubtedly examples of *V. parva*. The type of *Lucina ? solidula*, so far as one can judge from the figure, seems to have been rather shorter than most examples of *Venus parva*.

Venus Orbignyana, Forbes,[1] from the Crackers of Atherfield, is stated to be allied to *V. parva*. The type is missing, but a specimen named *V. Orbignyana* in the Museum of the Geological Society appears to be a small example of *Cyprina Saussuri* (p. 131).

Remarks.—Examples of this species vary somewhat in convexity, in relative height and length, in the prominence and position of the umbones, and in the projection of the lunule at the margin where the valves meet. The types are internal casts from Parham, and they agree, except in being slightly more convex, with casts from East Shalford, where specimens with the shell preserved are also found. The latter do not differ from the perfectly preserved specimens found in the Crackers of Atherfield.

Type.—From the Sandgate Beds of Parham Park, in the British Museum.

Distribution.—Lower Greensand: *Perna*-bed, Crackers, and Bed 45 of Atherfield. *Perna*-bed of Sandown. Atherfield Beds of Peasmarsh and Shalford. Sandgate Beds of Parham Park.

CYPRIMERIA (CYCLORISMA) ROTOMAGENSIS (*d'Orbigny*), 1845. Plate XXIX, figs. 4—6.

1845. VENUS RHOTOMAGENSIS, *A. d'Orbigny*. Pal. Franç. Terr. Crét., vol. iii, p. 443, pl. ccclxxxv, figs. 1—5.
1850. — ROTHOMAGENSIS, *d'Orbigny*. Prodr. de Pal., vol. ii, p. 194.
1865. — ROTOMAGENSIS, *F. J. Pictet and G. Campiche*. Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 190.
1870. — — *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 161 (*? Caryatis*).

Remarks.—The English examples of this species are internal casts occasionally with small portions of the shell preserved. D'Orbigny's specimens were obtained

[1] 'Quart. Journ. Geol. Soc.,' vol. i (1845), p. 240, pl. ii, fig. 5; d'Orbigny, 'Prodr. de Pal.,' vol. ii (1850), p. 118; Morris, 'Cat. Brit. Foss.,' ed. 2 (1854), p. 231; Pictet and Campiche, 'Foss. Terr. Crét. Ste. Croix' ('Matér. Pal. Suisse,' ser. 4, 1865). pp. 184, 188; Stoliczka, 'Palæont. Indica, Cret. Fauna S. India,' vol. iii (1870), p. 160.

from the Cenomanian of Rouen. English specimens agree with those found at Rouen, except that in many cases the shell is somewhat shorter relatively. The surface is ornamented with concentric ribs. In *C.* (*Cyclorisma*) *rotomagensis* the shell is more convex, more inequilateral, and the postero-dorsal margin has a greater slope than in *C.* (*Cyclorisma*) *parva*. The hinge appears to be unknown.

Distribution.—Base of the Chalk Marl of Maiden Newton and Chard. Chloritic Marl of Melbury, Woolcombe, Maiden Bradley and the Isle of Wight.[1]

Cyprimeria (Cyclorisma) faba (*Sowerby*), 1827. Plate XXIX, figs. 7—13.

1827. Venus faba, *J. de C. Sowerby.* Min. Conch., vol. vi, p. 129, pl. dlxvii, fig. 3.
1850. — — *A. d'Orbigny.* Prodr. de Pal., vol. ii, p. 159 (*partim*).
1854. — — *J. Morris.* Cat. Brit. Foss., ed. 2, p. 230 (*partim*).
1868. — — *A. Briart and F. L. Cornet.* Meule de Bracquegnies (Mém. cour. et Mém. des Sav. étrangers, vol. xxxiv), p. 73, pl. viii, figs. 9, 10.
1870. — — *F. Stoliczka.* Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 160.
1873. — — *H. B. Geinitz.* Das Elbthalgeb. in Sachsen (Palæontographica, vol. xx, pt. 2), p. 65, pl. xviii, figs. 9, 10.
? 1882. — — *J. Kiesow.* Schrift. d. nat. Gesellsch. in Danzig, N.F., vol. v, p. 239.
? 1885. — — *F. Nötling.* Die Fauna d. baltisch. Cenoman. (Palæont. Abhandl., vol. ii), p. 32, pl. vi, fig. 1.

Non 1840. — — *A. Goldfuss.* Petref. Germ., vol. ii, p. 247, pl. cli, fig. 6 (*V. subfaba*, d'Orbigny).
— 1843. — — *H. B. Geinitz.* Die Verstein. von Kieslingswalda, p. 13, pl. ii, figs. 7—9.
? — 1845. — — *A. d'Orbigny.* Pal. Franç. Terr. Crét., vol. iii, p. 444, pl. ccclxxxv, figs. 6—8.
— 1846. — — *A. E. Reuss.* Die Verstein. der böhm. Kreideformat., pt. 2, p. 21, pl. xli, fig. 12.
— 1847. — — *J. Müller.* Petref. der Aachen. Kreidef., pt. 1, p. 24.
— 1859. — immersa, *Müller.* Ibid., Supplement, p. 13.
— 1863. — faba, *A. v. Strombeck.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xv, p. 147.

1 An imperfect left valve from the Cenomanian (Bed 12) of Whitecliff, South Devon, was identified by C. J. A. Meÿer with *Venus Goldfussi*, Geinitz, 'Das Quadersandst. oder Kreidegeb. in Deutschland' (1850), p. 154, pl. x, figs. 7, 8; 'Das Elbthalgeb. in Sachsen' ('Palæontographica,' vol. xx, pt. 2, 1873), p. 67, pl. xviii, figs. 16, 17. There is not sufficient evidence to confirm this identification; the anterior part of the specimen is more produced than in the case of the examples figured by Geinitz.

Non 1863. VENUS FABA, *R. Drescher.* Ibid., vol. xv, p. 343.
— 1884. CYPRIMERIA FABA, *E. Holzapfel.* Ibid., vol. xxxvi, p. 467, pl. vii, fig. 1.
— 1889. TAPES FABA, *E. Holzapfel.* Die Mollusk. Aachen. Kreide (Palæontographica, vol. xxxv), p. 165, pl. xiii, figs. 7–10.
— 1897. VENUS (TAPES) FABA, *A. Fritsch.* Stud. im Gebiete der böhm. Kreideformat., vi, Chlomek. Schicht, p. 63, fig. 80.
— 1901. — — — *F. Sturm.* Jahrb. d. k. preussisch. geol. Landesanst. für 1900, vol. xxi, p. 82.

Description.—Shell oval, of moderate convexity, with flattened sides, considerably inequilateral. Antero-dorsal margin short, slightly concave. Anterior margin rounded, passing gradually into the slightly convex ventral margin. Postero-dorsal margin long, slightly convex, with a moderate or considerable ventral slope. Porterior margin short, rounded or subtruncate. Umbones small. Lunule elongate, not impressed, faintly limited. Ornamentation consists of small, regular, concentric ribs.

Hinge: In the right valve the anterior and median cardinals are stout, diverge slightly, and are directed forwards, and reach the lower margin of the hinge-plate; the two posterior teeth (which represent the posterior cardinal) are laminar, oblique and diverging. In the left valve the anterior and median cardinals are rather stout and diverge; the posterior cardinal is slender and oblique. In front of the anterior cardinal there is a concave space on the hinge-plate in both valves.

Measurements:

	(1)	(2)	(3)	(4)	(5)
Length .	30 .	29 .	29 .	28 .	27 mm.
Height .	25 .	24 .	22 .	21 .	22 ,,

(1—5) Blackdown.

Affinities.—*Venus Archiaciana*, d'Orbigny,[1] from the Senonian of Charente-Inférieure, is somewhat similar in form to *C.* (*Cyclorisma*) *faba*, but the surface of the shell is smooth.

A species found in the Aachen Greensand has been identified by Goldfuss, Holzapfel, and others with Sowerby's *Venus faba*, but was regarded as distinct by d'Orbigny and G. Müller. It differs from Sowerby's species in the greater curvature of the ventral margin and the more pointed posterior extremity; also the posterior teeth in the right valve are less widely separated and are more oblique.

In d'Orbigny's figure of *Venus faba* the ornamentation is coarser than in English examples, but a specimen from the Cenomanian of Rouen (one of the localities cited by d'Orbigny) differs but little in this respect from Blackdown specimens.

Remarks.—The principal variation consists in the amount of the ventral slope

[1] 'Pal. Franç. Terr. Crét.,' vol. iii (1845), p. 449, pl. ccclxxxvi, figs. 6, 7.

of the postero-dorsal margin. In the type specimen that slope is small, so that the outline of the shell is distinctly oval. The position of the umbones also varies, so that some specimens are more inequilateral than others.

Specimens found in the Gault of Black Ven are usually somewhat crushed and often larger than Blackdown examples; some are more elongate and agree closely with *Venus sublævis*, Sowerby (see below).

Type.—From Blackdown; in the British Museum.

Distribution.—Upper Greensand (zone of *Schlœnbachia rostrata*) of Blackdown and (?) Devizes. Gault of Black Ven.

Cyprimeria (Cyclorisma) sublævis (*Sowerby*), 1836. Plate XXIX, fig. 14.

1836. Venus? sublævis, *J. de C. Sowerby*. Trans. Geol. Soc., ser. 2, vol. iv, pp. 242, 342, pl. xvii, fig. 5.
1850. Venus sublævis, *A. d'Orbigny*. Prodr. de Pal., vol. ii, p. 159.
1854. — — *J. Morris*. Cat. Brit. Foss., ed. 2, p. 231.
1870. — — *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 161.

Remarks.—The only specimen which I have seen is the type. It differs from *C.* (*Cyclorisma*) *faba* only in being more elongate, and seems to be merely an individual variation. *Venus immersa*, Sowerby,[1] also known by the type only (Plate XXIX, fig. 15), does not appear to differ from *V. sublævis*. The types of both are in the Bristol Museum and come from the Upper Greensand of Blackdown.

Genus—Clementia, *J. E. Gray*, 1840.

('Synopsis Brit. Mus.,' p. 149.)

Sub-genus—Flaventia, *A. J. Jukes-Browne*, 1908.

('Proc. Malacol. Soc.,' vol. viii, p. 167.)

Clementia (Flaventia) Ricordeana (*d'Orbigny*), 1845. Plate XXIX, figs. 16—18.

1845. Venus Ricordeana, *A. d'Orbigny*. Pal. Franç. Terr. Crét., vol. iii, p. 431, pl. ccclxxxii, figs. 1, 2.

[1] Sowerby, 'Trans. Geol. Soc.,' ser. 2, vol. iv (1836), pp. 242, 342, pl. xvii, fig. 6; d'Orbigny, 'Prodr. de Pal.,' vol. ii (1850), p. 159; Morris, 'Cat. Brit. Foss.,' ed. 2 (1854), p. 231; Stoliczka, 'Palæont. Indica, Cret. Fauna S. India,' vol. iii (1870), p. 161. Non *Venus immersa*, Müller, 'Petref. der Aachen. Kreidef.,' Supplement (1859), p. 13; Reuss, 'Die Verstein. der böhm. Kreideformat.,' pt. 2 (1846), p. 20, pl. xli, fig. 11; Kner, 'Denkschr. d. k. Akad. Wissensch. Wien, Math.-Nat. Cl.,' vol. iii (1852), p. 311, pl. xvi, fig. 20.

1850.	Venus Ricordeana,	*A. d'Orbigny.*	Prodr. de Pal., vol. ii, p. 76.
1855.	— —	*G. Cotteau.*	Moll. Foss. de l'Yonne, p. 64.
1865.	— —	*F. J. Pictet and G. Campiche.*	Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 169.
1870.	— —	*F. Stoliczka.*	Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 159.

Description.—Shell oval, convex with flattened sides, considerably inequilateral, anterior part higher than the posterior part. Anterior margin regularly rounded, passing gradually into the slightly curved ventral margin. Postero-dorsal margin long, convex, with a considerable ventral slope. Posterior margin short, oblique, forming a rounded angle with the ventral margin. Umbones broad, curved forwards. The part of the shell behind a line between the umbones and the postero-ventral angle slopes rapidly from the flattened sides. Lunule elongate, limited by a groove. Escutcheon elongate, deep, limited by a sharp edge.

Ornamentation consists of sharp concentric ridges. Pallial sinus angular, somewhat ascending.

Measurements :

	(1)	(2)	(3)	(4)	(5)
Length	56	52	52	50	43 mm.
Height	47	40	39	35	34 „

(1) Atherfield Beds, Peasmarsh.
(2, 5) *Perna*-bed, Atherfield.
(3) Hythe Beds, Lympne.
(4) Hythe Beds, Pulborough.

Affinities.—English specimens differ from d'Orbigny's figure in the more rapid ventral slope of the postero-dorsal margin. I am indebted to Professor Boule for comparing photographs of specimens from the Lower Greensand with the examples in the d'Orbigny collection which appear to be the types, and he states that in the latter the shell is less elongate and the postero-dorsal border has a greater slope than in d'Orbigny's figure, consequently the photographs agree much more closely with the types than with the figure. M. A. de Grossouvre has been good enough to lend me a specimen of *C.* (*Flaventia*) *Ricordeana* from the Lower Aptian of Seignelay, Yonne, one of the localities mentioned by d'Orbigny, and a comparison of that with English examples leaves no doubt as to their specific identity.

The generic position of *Clementia* (*Flaventia*) *Ricordeana* is at present somewhat uncertain since none of the specimens shows the hinge; but on account of the resemblance in the form of the shell to that of *C.* (*Flaventia*) *ovalis* it is probable that this species belongs to the sub-genus *Flaventia*. *C.* (*Flaventia*)

Ricordeana is less elongate and its postero-dorsal margin is more convex and slopes more rapidly than in *Venus sub-Brongniartiana* d'Orbigny.[1]

Remarks.—This is probably the species which has been recorded by some authors from the Lower Greensand as *Venus ovalis* and *Astarte substriata*, Leymerie. The proportions of length and height vary considerably in different specimens.

Distribution.—Lower Greensand (*Perna*-bed) of Atherfield. Atherfield Beds of East Shalford, Redhill, and Peasmarsh. Hythe Beds of Hythe, Lympne, and Pulborough.

CLEMENTIA (FLAVENTIA) OVALIS (*Sowerby*), 1827. Plate XXIX, figs. 19—26.

1827. VENUS OVALIS, *J. de C. Sowerby.* Min. Conch., vol. vi. p. 129, pl. dlxvii, fig. 1 (not fig. 2).
1850. — — *A. d'Orbigny.* Prodr. de Pal., vol. ii, p. 159.
1854. — — *J. Morris.* Cat. Brit. Foss., ed. 2, p. 231 (not from the localities given).
1870. — — *F. Stoliczka.* Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 160.

Non 1840. — — *A. Goldfuss.* Petref. Germ., vol. ii, p. 247, pl. cli, fig. 5 (*Venus subovalis*, d'Orbigny, 1850).
— 1846. — — *A. E. Reuss.* Die Verstein. der böhm. Kreideformat., pt. 2, p. 21, pl. xxxiv, fig. 22.
— 1847. — — *J. Müller.* Petref. der Aachen. Kreidef., pt. 1, p. 24.
— 1870. — — *H. Credner.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xx, p. 191.
— 1884. CYTHEREA OVALIS, *E. Holzapfel.* Ibid., vol. xxxvi, p. 464, pl. vii, figs. 2—4.
— 1888. — — *G. Müller.* Jahrb. d. k. preussisch. geol. Landesanst. für 1887, p. 427.
— 1889. — — *E. Holzapfel.* Die Mollusk. Aachen. Kreide (Palæontographica, vol. xxxv), p. 169, pl. xiii, figs. 11—15.
— — VENUS — *A. Fritsch.* Stud. im Gebiete der böhm. Kreideformat., iv, Teplitz. Schicht., p. 80, fig. 69.
— 1898. CYTHEREA — *G. Müller.* Mollusk. d. Untersen. v. Braunschweig u. Ilsede, p. 66. pl. ix, fig. 15.
— 1901. — — *F. Sturm.* Jahrb. d. k. preussisch. geol. Landesanst. für 1900, vol. xxi, p. 83.

Description.—Shell elongate-oval, of moderate convexity, considerably inequilateral. Antero-dorsal margin rather long, concave. Anterior margin rounded,

[1] Leymerie, 'Mém. Soc. géol. de France,' ser. 2, vol. v (1842), pp. 5, 25, pl. v, fig. 7; d'Orbigny, 'Pal. Franç. Terr. Crét.,' vol. iii (1845), p. 432, pl. ccclxxxii, figs. 3—6; Pictet and Campiche, 'Terr. Crét. Ste. Croix' (1865), p. 168, pl. cxi, fig. 1.

passing gradually into the considerably curved ventral margin. Postero-dorsal margin long, convex. Posterior margin short, rounded. Umbones prominent, pointed, with a considerable anterior curvature. Lunule ovate, faintly limited.

Ornamentation consists of growth-rings and (in well-preserved specimens) of numerous small, regular, concentric ribs. Pallial sinus deep, ascending, with rounded end.

Hinge: In the right valve the anterior and median cardinals are strong, and diverge below the umbo; the posterior cardinal is long, oblique, curved, and divided into two parts of which the anterior is shorter than the posterior. In the left valve the anterior and median cardinals are strong and diverge below the umbo; the posterior cardinal is laminar and very oblique.

Measurements :

	(1)	(2)	(3)	(4)	(5)	(6)	
Length	44	40	37	34	32	30	mm.
Height	33	31	32	26	27	23	,,

(1—6) Blackdown.

Affinities.—The form from the Aachen Greensand which was referred to this species by Goldfuss and others possesses an anterior lateral tooth.

Remarks.—In Sowerby's figure the lunule projects more than in any specimen which I have seen, but in other respects the examples from Blackdown agree with that figure.

Type.—The type came from Blackdown, but cannot now be found.

Distribution.—Upper Greensand (zone of *Schlœnbachia rostrata*) of Blackdown.[1] Recorded by Jukes-Browne from the Upper Greensand of Devizes.

Genus—Callista, *O. A. L. Mörch*, 1853.

('Catalog. Conchyl. de Yoldi,' ii, p. 27.)

Callista plana (*Sowerby*), 1813. Plate XXX, figs. 1—6.

1813. Venus planus, *J. Sowerby.* Min. Conch., vol. i, p. 58, pl. xx, lower figures.
1854. Cytherea plana, *J. Morris.* Cat. Brit. Foss., ed. 2, p. 201.
? 1845. Venus plana, *A. d'Orbigny.* Pal. Franç. Terr. Crét., vol. iii, p. 447, pl. ccclxxxvi, figs. 1—3 (? *partim*).

[1] The type of *Venus submersa*, Sowerby, from the Upper Greensand of Pinhay, cannot be found. I have seen no specimen which could be referred to that species. Barrois, however, records it from the Upper Greensand of Lulworth. J. de C. Sowerby, 'Trans. Geol. Soc.,' ser. 2, vol. iv (1836), pp. 242, 342, pl. xvii, fig. 4; d'Orbigny, 'Prodr. de Pal.,' vol. ii (1850), p. 159; Morris, 'Cat. Brit. Foss.,' ed. 2 (1854), p. 231; Stoliczka, 'Palæont. Indica, Cret. Fauna S. India,' vol. iii (1870), p. 161 (*Caryatis*) Barrois, 'Terr. Crét. Supér. de l'Anglet. et de l'Irelande' (1876), p. 90.

1850. VENUS PLANA, *A. d'Orbigny.* Prodr. de Pal., vol. ii, p. 159.
1865. — — *F. J. Pictet and G. Campiche.* Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 190.
1867. — — *E. Guéranger.* Album Paléont. de la Sarthe, p. 13, pl. xvii, fig. 11.
1868. — — *A. Briart and F. L. Cornet.* Meule de Bracquegnies (Mém. cour. et Mém. des Sav. étrangers, vol. xxxiv), p. 72, pl. viii, figs. 3—5.

? Non 1846. VENUS PLANA, *A. E. Reuss.* Die Verstein. der böhm. Kreideformat., pt. 2, p. 21, pl. xli, fig. 14.
? — 1879. CYTHEREA (CARYATIS) PLANA, *J. F. Whiteaves.* Mesoz. Foss., vol. i (Geol. Surv. Canada), p. 149, pl. xvii, fig. 14.

Description.—Shell oval, sometimes more or less triangular, rounded, moderately convex, considerably inequilateral; length greater than height. Antero-dorsal margin long, concave. Anterior part of valve more or less produced, with rounded margin. Ventral margin forming a considerable curve. Posterior margin short, rounded or slightly truncate. Postero-dorsal margin convex, much longer than the antero-dorsal margin. Umbones rather prominent, pointed, close together, curved anteriorly. Lunule long, cordiform, distinctly limited. Escutcheon not defined. Ornamentation consists of small concentric ridges, with stronger growth-ridges at intervals. Fine radial ribbing is occasionally seen in the posterior part of well-preserved specimens. Pallial sinus fairly large, angular or sub-angular, slightly ascending.

Hinge: In the right valve the anterior and median cardinals are nearly vertical, slightly diverging, and separated dorsally, the posterior cardinal is oblique, long and divided, its posterior part is much longer than the anterior part, and the latter nearly meets the anterior cardinal under the umbo; in front of the cardinal teeth there is a shallow, elongate pit with slightly raised upper and lower margins. In the left valve the stout anterior and median cardinals diverge from under the umbo, the anterior tooth being nearly vertical; there is a long slender, oblique posterior cardinal, and an elongate, ridge-like anterior lateral tooth, which is grooved or corrugated.

Measurements:

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Length .	72	69	63	62	54	52	48	44	35 mm.
Height .	63	57	53	51	46	43	41	37	29 ,,

(1—9) Blackdown.

Affinities.—Specimens from Senonian deposits of Europe have been referred to

Venus planus, Sowerby, by several authors;[1] and so far as I can judge from the few figures which have been published, they seem to differ but little from Sowerby's species. The example from Aachen figured by Goldfuss agrees closely with specimens from Blackdown except that the lunule projects more at the margin. Holzapfel has compared Aachen with Blackdown specimens, and confirms Goldfuss's identification. The example figured by d'Orbigny[2] differs in having a large and deep escutcheon.

Specimens from the Trichinopoli Group (near the base of the Ariyalúr Group) were identified by Stoliczka[3] with *Venus planus.*

The absence of a channel under the anterior right cardinal, and the occurrence of fine radial ornamentation connect this species with *Callista*. The pallial sinus, however, resembles that of *Pitaria*. The anterior lateral tooth in the left valve is much less prominent, and the corresponding pit in the right valve much smaller and shallower than in either *Callista* or *Pitaria*. This species is the type of the section or sub-genus *Callistina*, Jukes-Browne.[4]

Remarks.—This is a common fossil at Blackdown. The variations seen consist in the proportion of height to length, the more or less triangular or oval outline, and the more or less produced anterior part of the shell.

Type.—From Blackdown; in the British Museum.

Distribution.—Upper Greensand (zone of *Schlœnbachia rostrata*) of Blackdown and Haldon. Recorded by Jukes-Browne from the Upper Greensand of Devizes, the Isle of Wight, etc.

Family—CARDIIDÆ, *Lamarck.*

Genus—PROTOCARDIA, *E. Beyrich*, 1845.

('Menke's Zeitschr. f. Malakozool.,' p. 17.)

PROTOCARDIA ANGLICA, sp. nov. Plate XXX, figs. 7 *a*, *b*; Plate XXXI, fig. 1.

Description.—Shell large, convex, with flattened sides, subquadrate, moderately

[1] Goldfuss, 'Petref. Germ.,' vol. ii (1840), p. 238, pl. cxlviii, fig. 4; Müller, 'Petref. der Aachen. Kreidef.,' (1847), pt. 1, p. 25; Drescher, 'Zeitschr. d. deutsch. geol. Gesellsch.,' vol. xv (1863), p. 344; Brauns, 'Zeitschr. f. d. gesammt. Naturwiss.,' vol. xlvi (1876), p. 368; H. Schröder, 'Zeitschr. d. deutsch. geol. Gesellsch.,' vol. xxiv (1882), p. 275; Holzapfel, 'Die Mollusk. Aachen. Kreide' ('Palæontographica,' vol. xxxv, 1889), p. 171, pl. xiii, figs. 16—18; Vogel, 'Holländisch. Kreide' (1895), p. 42.

[2] D'Orbigny subsequently separated the Senonian form under the name *Venus subplana*, 'Prodr. de Pal.,' vol. ii (1850), p. 237. See also *V. Renauxiana*, d'Orbigny, ibid., p. 194.

[3] Stoliczka, 'Palæont. Indica, Cret. Fauna S. India,' vol. iii (1870), pp. 151, 160, 169, pl. vii, figs. 1—4.

[4] Proc. Malacol. Soc., vol. viii (1908), p. 156.

inequilateral, length and height nearly equal. Antero-dorsal margin nearly straight. Anterior margin convex, curving rapidly to join the ventral margin, which is moderately or slightly convex. Posterior margin truncated, forming angles with the ventral and postero-dorsal margins. Umbones large, curved forwards, with a sharp carina extending in a curve to the postero-ventral angle and limiting the flattened, steeply-sloping posterior area, the dorsal portion of which is concave. Shell depressed in front of the umbones.

Ornamentation: Sides of shell nearly smooth except for numerous, very small, concentric ribs which are separated by flat interspaces. The posterior area is covered, except near the postero-dorsal margin, by 12 strong radial ribs.

Measurements :

	(1)	(2)	(3)	
Length .	80 .	76 .	46	mm.
Height .	78 .	79 .	46	,,

(1—3) Crackers, Atherfield.

Affinities.—This species resembles *P. Forbesi* (Pictet and Renevier),[1] from the Lower Aptian of Ste. Croix, but the umbones are less prominent, and the ribs on the posterior area are less numerous.

It is also similar to *P. impressa* (Deshayes),[2] but is distinguished by the smaller curvature of the ventral margin, the greater flattening of the sides of the shell, and the more considerable curvature of the umbones.

Distribution.—Lower Greensand (Crackers) of Atherfield.[3]

PROTOCARDIA SPHÆROIDEA (*Forbes*), 1845. Plate XXXI, figs. 2, 3.

1845. CARDIUM SPHÆROIDIUM, *E. Forbes.* Quart. Journ. Geol. Soc., vol. i, p. 243. pl. ii, fig. 8.
1850. — — *A. d'Orbigny.* Prodr. de Pal., vol. ii, p. 79.
1852. — NECKERIANUM, *F. J. Pictet and W. Roux.* Moll. Foss. Grès verts de Genève, pp. 424, 425, pl. xxx, fig. 3.
— — SPHÆROIDEUM, *Pictet and Roux.* Ibid., p. 546.
1854. — — *J. Morris.* Cat. Brit. Foss., ed. 2, p. 193.

[1] 'Foss. Terr. Aptien' ('Matér. Pal. Suisse,' ser 1, 1856), p. 79, pl. viii, fig. 4; Pictet and Campiche, 'Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4, 1866), p. 261.

[2] D'Orbigny, 'Pal. Franç. Terr. Crét.,' vol. iii (1844), p, 20, pl. ccxl; Pictet and Campiche, *op. cit.*, p. 249.

[3] Some specimens of *Protocardia* from the Lower Greensand of Atherfield were referred by Forbes to *Cardium peregrinorsum,* d'Orbigny, but that identification was doubted by Pictet and Campiche. The specimens at present available are insufficient for exact determination. See Forbes, 'Quart. Journ. Geol. Soc.,' vol. i (1845), p. 243.

1856. CARDIUM SPHÆROIDEUM, *F. J. Pictet and E. Renevier.* Foss. Terr. Aptien (Matér. Pal. Suisse, ser. 1), p. 77, pl. ix, fig. 3.
1866. — — *F. J. Pictet and G. Campiche.* Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 260.
1871. — — (? LÆVICARDIUM), *F. Stoliczka.* Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 213.

Description.—Shell stout, large, much inflated, higher than long, slightly inequilateral. Anterior and ventral margins rounded. Posterior margins truncated, forming angles with the postero-dorsal and ventral margins. Umbones prominent, with a small forward curvature, and an inconspicuous carina extending to the postero-ventral angle and limiting the flattened postero-dorsal area.

Ornamentation consists of regular, broad, flat, concentric ribs separated by narrow grooves. On the posterior area strong growth-ridges are present.

Measurements :

	(1)	(2)	(3)	(4)	(5)	
Length	79	76	73	69	47	mm.
Height	84	91	87	87	48	,,

(1—5) *Perna*-bed, Isle of Wight.

Affinities.—Pictet and Campiche state that this species is very near to *C. imbricatarium* (Deshayes),[1] but that the posterior area is more flattened and forms an angle with the sides of the shell; also the truncated posterior margin is relatively longer.

Remarks.—In this species the radial ornamentation of the posterior area is either very indistinct or quite obsolete. There is considerable variation in relative height and length of the shell.

Type.—From the Lower Greensand (*Perna*-bed) of Sandown; in the Museum of the Geological Society.

Distribution.—Lower Greensand (*Perna*-bed) of Atherfield and Sandown. Recorded by Topley from the Hythe Beds of Hythe.

PROTOCARDIA, sp. Plate XXXI, fig. 4.

The collection of Upper Greensand fossils made by the late W. Vicary, which is now in the British Museum, contains two imperfect right valves (No. L 17041)

[1] D'Orbigny, 'Pal. Franç. Terr. Crét.' (1844), vol. iii, p. 18, pl. cccxxxix, figs. 4—6; Leymerie, 'Mém. Soc. géol. de France,' ser. 2, vol. v (1842), p. 4, pl. v, fig. 2; Pictet and Campiche, 'Terr. Crét. Ste. Croix' ('Matér. Pal. Suisse,' ser. 4, 1866), p. 258, pl. cxxi, figs. 6, 7. The specimens referred to *C. imbricatarium* by Forbes are examples of *Unicardium vectense* (p. 163); see Forbes, 'Quart. Journ. Geol. Soc.,' vol. i (1845), p. 243.

from Haldon, which resemble in shape the higher forms of *P. sphæroidea*, but the umbones are narrower and more curved, and the carina is more distinct. Better specimens are needed before a satisfactory comparison can be made. The occurrence of *P. sphæroidea* in the Upper Greensand (zone of *Pecten asper*) of Wiltshire has been recorded by Mr. Jukes-Browne.

PROTOCARDIA, sp. Plate XXXI, fig. 5 *a*, *b*.

Description.—Shell globose, with rounded outline, slightly inequilateral, height and length nearly equal. Umbones low, curved anteriorly. The posterior part of the shell (except near the postero-dorsal margin) is ornamented with from ten to twelve strong radial ribs; the remainder of the shell bears numerous, small concentric ribs.

Affinities.—This species resembles *P. peregrinorsa* (d'Orbigny),[1] but the area with radial ribs is relatively larger, and the concentric ribs are finer.

Remarks.—The only specimens seen are two in the Museum of Practical Geology and two in Mr. Lamplugh's collection.

Distribution.—Speeton Clay (zone of *Belemnites lateralis*, D, 4) of Speeton.[2]

PROTOCARDIA HILLANA (*Sowerby*), 1813. Plate XXXI, figs. 6 *a*—*c*; Plate XXXII, fig. 1—6.

1813.	CARDIUM	HILLANUM,	*J. Sowerby.*	Min. Conch., vol. i, p. 41, pl. xiv (upper figure).
1819.	—	—	*Lamarck.*	Hist. nat. Anim. sans Vert., vol. vi, p. 20.
1837.	—	—	*A. Goldfuss.*	Petref. Germ., vol. ii, p. 220, pl. cxliv, fig. 4.
—	—	—	*F. Dujardin.*	Mém. Soc. géol. de France, vol ii p. 224.
1840.	—	—	*H. B. Geinitz.*	Char. d. Schicht. u. Petref. des sächs. Kreidegeb., pt. 2, p. 53.
1841.	—	—	*F. A. Römer.*	Die Verstein. d. nord-deutsch. Kreidegeb., p. 71.
1842.	—	REQUENIANUM,	*P. Matheron.*	Catal. Foss. du Départ. des Bouches-du-Rhône, p. 157, pl. xviii, fig. 6.

[1] 'Pal. Franç. Terr. Cret.,' vol. iii (1844), p. 16, pl. ccxxxix, figs. 1—3; Pictet and Campiche, 'Terr. Crét. Ste. Croix' ('Matér. Pal. Suisse,' ser. 4, 1866), p. 254, pl. cxxi, figs. 1, 2.

[2] Internal casts of a globose and nearly equilateral "*Cardium*" (perhaps *Protocardia*), from the Spilsby Sandstone of Donnington, are in the Sedgwick Museum.

1843. CARDIUM HILLANUM, *H. B. Geinitz.* Die Verstein. von Kieslingswalda, p. 13, pl. ii, figs. 10, 11.
1844. — — *A. d'Orbigny.* Pal. Franç. Terr. Crét, vol. iii, p. 27, pl. ccxliii.
1845. PROTOCARDIA HILLANA, *E. Beyrich.* Menke's Zeitschr. f. Malakozool., p. 18.
1846. — — *A. E. Reuss.* Die Verstein. der böhm. Kreideformat., pt. 2, p. 22, pl. xlv, fig. 2.
— — — *H. B. Geinitz.* Grundr. d. Verstein., p. 421, pl. xix, fig. 4.
? — CARDIUM HILLANUM, *E. Forbes.* Trans. Geol. Soc., ser. 2, vol. vii, p. 146.
1850. — — *A. d'Orbigny.* Prodr. de Pal., vol. ii, p. 162.
— PROTOCARDIA HILLANA, *H. B. Geinitz.* Das Quadersandst. oder Kreidegeb. in Deutschland, p. 154.
? 1852. CARDIUM HILLANUM, *F. Römer.* Kreidebild. v. Texas, p. 49, pl. vi, fig. 12.
— PROTOCARDIA HILLANA, *H. G. Bronn.* Lethæa Geogn., vol. ii, p. 302, pl. xxx, fig. 12.
1854. CARDIUM BIFRONS, *A. E. Reuss.* Kreideschicht. i. d. Ostalpen, p. 145, pl. xxviii, fig. 19.
— HILLANUM, *J. Morris.* Cat. Brit. Foss., ed. 2, p. 192.
1863. PROTOCARDIA HILLANA, *R. Drescher.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xv, p. 346,
1864. CARDIUM (PROTOCARDIA) HILLANA, *K. A. Zittel.* Die Bivalv. d. Gosaugeb., I, p. 42 [146], pl. vii, figs. 1, 2.
1866. — HILLANUM, *F. J. Pictet and G. Campiche.* Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), pp. 268, 273.
? 1867. — — *O. Fraas.* Aus dem Orient, I, p. 91.
— — — *E. Guéranger.* Album Paléont. de la Sarthe, p. 15, pl. xx, figs. 3, 11.
1868. — — *A. Briart and F. L. Cornet.* Meule de Bracquegnies (Mém. cour. et Mém. des Sav. étrangers, vol. xxxiv), p. 66, pl. vii, figs. 4, 5.
1870. PROTOCARDIA HILLANA, *F. Römer.* Geol. v. Oberschles., p. 334, pl. xxvi, fig. 2.
? 1871. PROTOCARDIUM HILLANUM, *F. Stoliczka.* Palæont. Indica, Cret. Fauna S. India, vol. iii, pp. 209, 219, pl. xii, figs. 8—10, pl. xiii, figs. 1—3.
1873. — — *H. B. Geinitz.* Das Elbthalgeb. in Sachsen (Palæontographica, vol. xx, pt. i), p. 230, pl. l, figs. 11, 12.
— CARDIUM — var. MOABITICUM, *L. Lartet.* Ann. Sci. géol., vol. iii, p. 53, pl. xii, fig. 9.
1876. PROTOCARDIA HILLANA, *D. Brauns.* Zeitschr. f. d. gesammt. Naturwiss., vol. xlvi, p. 266.
1877. PROTOCARDIUM HILLANUM, *A. Fritsch.* Stud. im Gebiete der böhm. Kreideformat., ii, Weissenberg. u. Malnitz. Schicht., p. 112, fig. 64.

? 1878. Protocardium Hillanum, *O. Fraas.* Aus dem Orient. II Geol. Beobacht. am Libanon, p. 70.

1882. Cardium (Protocardium) Hillanum, *P. de Loriol.* Gault de Cosne, p. 69, pl. viii, fig. 17.

1884. Protocardium Hillanum, *J. F. Whiteaves.* Mesoz. Foss. (Geol. Surv. Canada), vol. i, p. 228, pl. xxx, fig. 5.

? – Cardium (Protocardia) Hillanum, *C. E. Hamlin.* Mem. Mus. Comp. Zool., vol. x, No. 3, p. 50.

1893. Protocardium Hillanum, *R. Michael.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xlv, p. 232.

1897. — — *A. Fritsch.* Stud. im Gebiete der böhm. Kreideformat., vi, Chlomek. Schicht., p. 52.

— — — *R. Leonhard.* Kreidef. in Oberschles. (Palæontographica, vol. xliv), p. 28.

1898. — — *A. Fritsch.* Stud. im Gebiete der böhm. Kreideformat., iii, Iserschicht., p. 98.

1901. Protocardia Hillana, *F. Sturm.* Jahrb. d. k. preussisch. geol. Landesanst. für 1900, vol. xxi, p. 79.

1902. — — *A. Quaas.* Kreidebild. in der libysch. Wüste (Palæontographica, vol. xxx, 2), p. 218, pl. xxiv, fig. 18.

1904. — — *R. Fortau.* Bull. Instit. Egyptien, ser. 4, no. 4, p. 331.

– — — var. umkwelanensis, *R. Etheridge, jun.* Second Rep. Geol. Surv. Natal and Zululand, p. 79, pl. i, fig. 16.

1906. — — var., *H. Woods.* Cret. Fauna of Pondoland (Ann. S. African Mus., vol. iv), p. 307, pl. xxxvii, fig. 6.

Description.—Shell convex, with flattened posterior slope, nearly equilateral; outline more or less sub-quadrate, rounded, sometimes nearly oval; usually a little higher than long, but rarely with the height and length equal. Anterior margin either fairly convex and forming a rounded angle with the antero-dorsal margin, or very convex and passing almost gradually into the antero-dorsal margin. Anterior margin passes gradually into the ventral margin, which may be considerably convex, but is usually only slightly convex, with its posterior part nearly straight and forming a more or less well-marked angle with the posterior margin. The latter is truncated, slightly convex, and forms an obtuse angle with the postero-dorsal margin. Umbones of moderate size.

Ornamentation consists (except on the posterior part of the shell) of numerous, very regular, rounded, concentric ribs separated by narrow furrows; these ribs become smaller or nearly obsolete near the antero-dorsal margin. On the posterior

slope of the shell, and sometimes for a short distance in front of it, are from 10 to 15 (usually 12 or 13) strong, more or less angular ribs, separated by broad furrows, both being crossed by well-marked growth-ridges. Sometimes some of these ribs are divided at their summits by a narrow, longitudinal groove. The ribs become rather smaller dorsally and are absent near the postero-dorsal margin. Internal margins of valves smooth, except the posterior part with radial ribs, which is serrate.

Measurements:

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	
Length	51	48	44	44	43	41	38	36	36	32	27	19	mm.
Height	47	47	44	42	41	39	36	36	34	29·5	26	18	,,

(1—12) Blackdown.

Affinities.—Although this species has a very wide geographical distribution and a long range in time, yet the principal variations seen in specimens found at different horizons and in different kinds of sediment consist in the number and coarseness of the concentric ribs. The modifications do not appear to be more than varietal, and such as would be found at the present day in examples of a widely distributed species.

In the example from the Cenomanian figured by d'Orbigny the shell is rather higher and the ornamentation coarser than in specimens from Blackdown, but in the latter respect it agrees with examples found by the late C. J. A. Meÿer in the Cenomanian of South Devon. One specimen from the Cenomanian of Sarthe, shown in Guéranger's photographic illustrations, agrees in its ornamentation with Blackdown examples.

The Cenomanian form figured by Römer (1870), and the examples from higher horizons figured by Geinitz (1843) and by Goldfuss agree closely with Blackdown specimens. Coarser ribbing is found in specimens from the Gault of Cosne, showing that that character is not limited to examples from horizons above the Blackdown Greensand.

Protocardia bifrons (Reuss) is more rounded than *P. Hillana*, but does not seem to be specifically distinct.

Cardium marticense, Matheron, and *C. Requienianum*, Matheron, were regarded by d'Orbigny and by Zittel as synonyms of *P. Hillana*.

Specimens from the Trichinopoli Group of Southern India were identified with *P. Hillana* by Forbes and by Stoliczka, who stated that they were unable to draw any line of separation between the Indian and European examples. The concentric ribbing is coarser in most of the Indian forms, and in some the smooth inner portion of the posterior area is relatively larger than in specimens from Blackdown.[1]

[1] See Stoliczka's fig. 10*a*.

P. delicatula, Stoliczka,[1] and *P. pondicheriense* (d'Orbigny),[2] are allied to *P. Hillana*.

P. biseriata (Conrad),[3] from Syria, possesses coarse concentric ribs, and is regarded by Blanckenhorn as a variety of *P. Hillana*.

Remarks.—Examples of this species are common at Blackdown, but probably on account of the uniformity of the conditions under which they lived, do not show any very striking variations.

There are some differences in the proportion of length and height; usually the former exceeds the latter slightly, but occasionally the two are equal. The outline of the shell is sometimes oval, but more usually subquadrate. The radial ribs vary in number from 10 to 15, and sometimes the area with these ribs is continued for a short distance in front of the posterior slope.

The number of concentric ribs in 10 mm. (measured between 34 mm. and 44 mm. from the umbo) varies from 15 to 19.

Type.—From Blackdown, in the British Museum.

Distribution.—Upper Greensand (zone of *Schlœnbachia rostrata*) of Blackdown, Haldon, Whitecliff (South Devon), Peak Hill near Sidmouth, Devizes, and Ventnor. Cenomanian of Dunscombe. Recorded by Jukes-Browne from the Chloritic Marl of the Isle of Wight.

Genus—Cardium, *Linnæus*.

('Syst. Nat.,' ed. 10, 1758, p. 678; ed. 12, 1766, p. 1121.)

Cardium Ibbetsoni, *Forbes*, 1845. Plate XXXII, figs. 7—10.

1845. Cardium Ibbetsoni, *E. Forbes.* Quart. Journ. Geol. Soc., vol. i, p. 243, pl. ii, fig. 9.
1854. — — *J. Morris.* Cat. Brit. Foss., ed. 2, p. 192.
1856. — — *F. J. Pictet and E. Renevier.* Foss. Terr. Aptien (Matér. Pal. Suisse, ser. 1), p. 78, pl. ix, figs. 1, 2.
1866. — — *F. J. Pictet and G. Campiche.* Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 262.
1871. — — (Lævicardium), *F. Stoliczka.* Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 213.

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1 'Palæont. Indica, Cret. Fauna S. India,' vol. iii (1871), p. 220, pl. xiii, fig. 8.

2 Stoliczka, ibid., p. 220, pl. xii, figs. 4—7.

3 'Official Report U. S. Exped. Dead Sea, etc.,' by W. F. Lynch (1852), p. 216, pl. vi, figs. 38, 39 (non 40); R. B. Newton, 'Geol. Mag.,' (1898), p. 400, pl. xv, fig. 11. *P. Hillana* var. *typica*, M. Blanckenhorn, 'Beitr. zur Geol. Syriens: Kreidesyst. in Mittel u. Nord-Syriens' (1890), p. 89.

Description.—Shell small, inflated, oval, a little higher than long, slightly inequilateral. Anterior margin rounded, passing gradually into the convex ventral margin. Posterior margin subtruncate, higher than the anterior margin. Umbones prominent, with a faint carina extending to the postero-ventral extremity and forming the limit of the flattened postero-dorsal area. Margins of valves serrate.

Ornamentation consists of numerous small, slightly-raised radial ribs separated by narrow grooves; anteriorly the ribs become gradually smaller and are absent or indistinct near the antero-dorsal margin; on the postero-dorsal area the ribs are stronger and the grooves broader than elsewhere, and the anterior margins of these ribs are sometimes serrate. In well-preserved specimens faint concentric linear ridges are seen.

Measurements :

	(1)	(2)	(3)	(4)	(5)
Length .	17 .	15·5 .	14·2 .	14 .	10·5 mm.
Height .	18 .	16·5 .	15 .	14·5 .	11 ,,

(1—5) Crackers, Atherfield.

Affinities.—See *C. Cottaldinum* (p. 203).

In form *C. Ibbetsoni* resembles *C. Raulinianum*, d'Orbigny,[1] but the latter is distinguished by its broader grooves which bear pointed projections.[2]

In the specimens figured by Pictet and Renevier from the Aptian of the Perte du Rhône the umbones are more prominent than in English examples of *C. Ibbetsoni*, but Pictet and Campiche, who were able to compare examples from Atherfield with those obtained from the Perte du Rhône, felt no doubt as to their specific identity.

Type.—From Atherfield, in the Museum of the Geological Society.

Distribution.—Lower Greensand (Crackers) of Atherfield.

[1] 'Pal. Franç. Terr. Crét.,' vol. iii (1844), p. 25, pl. ccxlii, figs. 7—11.

[2] *C. Raulinianum* is recorded by Morris from the Lower Greensand of the Isle of Wight, and by Topley from the Atherfield Beds of Peasmarsh and Shalford. Specimens from the Atherfield Clay were referred to *C. subhillanum*, Leymerie, by Forbes, but that identification was regarded as doubtful by Pictet and Campiche; the form of the shell cannot be made out satisfactorily, but the ornamentation resembles that of *C. Ibbetsoni*. An internal cast from the Lower Greensand of Upware was referred with doubt to *C. subhillanum* by W. Keeping ('Foss. Neoc. Upware and Brickhill,' 1883, p. 119); the specimen is now in the Sedgwick Museum, Cambridge, and seems to me insufficient for determination. A specimen with radial ribs, from the Lower Greensand of Maidstone, was named *Cardium Benstedi* by Forbes, but was too imperfect for figuring; the type is in the Museum of the Geological Society (No. 2124); no other specimen has been seen. Forbes, 'Quart. Journ. Geol. Soc.,' vol. i (1845), p. 244; Pictet and Campiche, 'Foss. Terr. Crét. Ste. Croix' ('Matér. Pal. Suisse,' ser 4, 1866), p. 267.

CARDIUM COTTALDINUM, *d'Orbigny*, 1844. Plate XXXII, fig. 11 *a—e*.

1844. CARDIUM COTTALDINUM, *A. d'Orbigny*. Pal. Franç. Terr. Crét., vol. iii, p. 22, pl. ccxlii, figs. 1—4.
1850. — — *d'Orbigny*. Prodr. de Pal., vol. ii, p. 79.
1866. — — *F. J. Pictet and G. Campiche*. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 246, pl. cxviii, figs. 1, 2.
1871. — — *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 212.
1883. — — *W. Keeping*. Foss., etc., Neoc. Upware and Brickhill, p. 118, pl. vi, fig. 4.
1884. — — *O. Weerth*. Die Fauna des Neocom. im Teutoburg. Walde (Palæont. Abhandl., vol. ii), p. 44, pl. ix, fig. 3.
— — OERLINGHUSANUM, *Weerth*. Ibid., p. 44, pl. ix, fig. 4.
1895. — COTTALDINUM, *G. Maas*. Zeitschr. der deutsch. geol. Gesellsch., vol. xlvii, p. 263, pl. vii, figs. 2, 3.
1900. — — *A. Wollemann*. Die Biv. u. Gastrop. d. deutsch. u. holländ. Neocoms (Abhandl. d. k. preussisch. geol. Land., N. F., pt. 31), p. 107.

Description.—Shell oval, inflated, slightly inequilateral, rather higher than long. Anterior and ventral margins rounded. Posterior margin more or less truncated. Umbones rather high, sharp, curved inward and forward, with an indistinct carina.

Ornamentation consists of numerous, small, regular, radial ribs, which are rather more prominent on the posterior area than on the sides of the shell.

Measurements :

Length	24 mm.
Height	25·5 „

Upware.

Affinities.—This species closely resembles *C. Ibbetsoni*, but differs in having the posterior area less flattened and the outline of the shell more rounded. The English specimens of *C. Cottaldinum* are larger than those of *C. Ibbetsoni*, but are not sufficiently numerous or well-preserved for exact comparison.

In *C. Cottaldinum* the shell is relatively higher than in *C. Voltzi*, Leymerie.[1]

C. landeronense, de Loriol,[2] appears to be closely related to *C. Cottaldinum*.

Type.—D'Orbigny's specimens came from the Neocomian of Wassy (Haute-

[1] For references see Pictet and Campiche, 'Terr. Crét. Ste. Croix' ('Matér. Pal. Suisse,' ser. 4, 1866), p. 247.

[2] P. de Loriol and V. Gilliéron, 'Urgonien Infér. de Landeron' (1869), p. 14, pl. i, fig. 12.

Marne), Brillon (Meuse), St. Sauveur and Auxerre (Yonne). The specimens figured by Keeping are in the Sedgwick Museum.

Distribution.—Lower Greensand of Upware.[1]

CARDIUM, sp. Plate XXXII, fig. 12 *a*, *b*.

Internal casts of a globose form of *Cardium* occur in the Lower Greensand of Seend and Faringdon. On one specimen (No. 21272, Museum of Practical Geology) a portion of the shell is preserved, and its ornamentation resembles that of *C. Ibbetsoni* and *C. Cottaldinum.* The form of the shell seems to be rather more like that of *C. Ibbetsoni* than of *C. Cottaldinum.*

CARDIUM, spp.

Specimens of *Cardium* from the Cenomanian of Dunscombe, South Devon, were referred by C. J. A. Meÿer to *C. alternans*, Reuss, and *C. alutaceum*, Goldfuss. Better preserved specimens are needed before these determinations can be confirmed.

CARDIUM TURONIENSE, *Woods*, 1897. Plate XXXII, figs. 13—15.

1897. CARDIUM TURONIENSE, *H. Woods.* Quart. Journ. Geol. Soc., vol. liii, p. 389, pl. xxvii, figs. 20—22.

Description.—Shell small, oval, higher than long, inequilateral, much inflated, postero-dorsal part compressed. Umbones prominent, with a considerable anterior curvature. Ornamentation consists of many strong radial ribs. Length, 6 mm.; height, 7 mm.

Affinities.—This species shows some resemblance to *C. cenomanense*, d'Orbigny,[2] but is more inequilateral owing to the much greater curvature of the umbones; also the ribs are less numerous, and tubercles appear to be absent from the grooves.

Type.—In the Sedgwick Museum, Cambridge.

Distribution.—Chalk Rock of Cuckhamsley.

[1] Some small specimens found in the Ferruginous Sands of Shanklin may perhaps be referred to *C. Cottaldinum*, but they are too imperfectly preserved for exact determination.

[2] 'Pal. Franç. Terr. Crét.,' vol. iii (1844), p. 37, pl. ccxlix, figs. 5—9.

Cardium, sp. Plate XXXII, fig. 16 *a*, *b*.

1897. Cardium, sp. cf. cenomanense, *H. Woods.* Quart. Journ. Geol. Soc., vol. liii, p. 389, pl. xxvii, figs. 23, 24.

Internal casts, similar in form to *C. cenomanense*, d'Orbigny, are found in the Chalk Rock of Cuckhamsley. A part of the shell is imperfectly preserved on one specimen and is ornamented with fine radial ribs. A cast measures: height, 8 mm.; length, 8 mm.; thickness, 7·5 mm.

Cardium, sp. Plate XXXII, fig. 17 *a*—*c*.

Two internal casts from the Chalk of Norwich (one of which was found by the late T. G. Bayfield) are in the British Museum (Nos. L 19443, L20103). The shell is much inflated, so that the height and thickness are approximately equal; the height is considerably greater than the length. The umbones are prominent. The postero-dorsal part of the shell is flattened and shows indications of fine radial ribs.

This species shows some resemblance to *C. ventricosum*, d'Orbigny,[1] but is relatively higher.

Sub-genus—Granocardium, *W. M. Gabb*, 1869.
("Geol. Survey California," 'Palæont.,' vol. ii, p. 266.)

Cardium (Granocardium) proboscideum, *Sowerby*, 1817. Plate XXXII, figs. 18, 19; Plate XXXIII, figs. 1—3.

1816. Cardita tuberculata, *J. Sowerby.* Min. Conch., vol. ii, p. 97, pl. cxliii. (Non *Cardium tuberculatum*, Linnæus).
1817. Cardium proboscideum, *J. Sowerby.* Min. Conch., vol. ii, p. 127, pl. clvi, fig. 1.
1835. — Gentianum, *J. de C. Sowerby.* Ibid. (Systematical Index), vol. vi, p. 242.
1854. — proboscideum, *J. Morris.* Cat. Brit. Foss., ed. 2, p. 193.
— — Gentianum, *Morris.* Ibid., p. 192.
1866. — proboscideum, *F. J. Pictet and G. Campiche.* Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 269.

[1] *C. ventricosum* is recorded from the Upper Greensand (zone of *Pecten asper*) of Lulworth by Barrois ('Terr. Crét. Supér. de l'Angleterre et de l'Irelande,' 1876, p. 92). I have not seen any English example of that species.

1866. Cardium Gentianum, *Pictet and Campiche.* Ibid., p. 269.
1871. — proboscideum, *F. Stoliczka.* Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 213 (*Acanthocardium*).
— — Gentianum, *Stoliczka.* Ibid., p. 213 (*Acanthocardium*).
1882. — proboscideum, *P. de Loriol,* Gault de Cosne, p. 91, pl. xi, fig. 4.
1900. — Gentianum, *E. T. Newton and A. J. Jukes-Browne.* In Jukes-Browne, Cret. Rocks of Britain, vol. i, p. 448.

Description.—Shell stout, very convex, oval, higher than long, slightly inequilateral. Anterior margin rounded; posterior margin truncated, forming an angle with the postero-dorsal margin. Umbones prominent.

Ornamentation consists of radial ribs separated by narrow grooves; the stronger ribs bear prominent, angular, laterally compressed tooth-like projections, which may be rather larger near the posterior margin than elsewhere; in the spaces between the stronger ribs are two (sometimes one or three) smaller ribs with similar but smaller tooth-like projections. Margins of valves toothed.

Measurements:

	(1)	(2)	(3)	(4)	(5)
Length	63	59	58	57	47 mm.
Height	74	70	68	65	54 ,,

(1—5) Blackdown.

Affinities.—A form from the Cenomanian was referred by d'Orbigny to *C. productum*, Sowerby,[1] the type of which comes from the Senonian of Gosau. This identification has been accepted by Zittel, Holzapfel and others, but not by Pictet and Campiche, and de Loriol. The specimen figured by d'Orbigny[2] is probably an example of *C. proboscideum*, Sowerby, and differs from *C. productum* in the distinct differentiation of the ribs into a larger series separated by smaller series.

The differences between *C. Gentianum* and *C. proboscideum* seem to be due entirely to their different modes of preservation. The former is found in the Upper Greensand of Devizes and Ventnor; the shell is absent, but the sand which filled the interior of the shell now forms a natural cast of the exterior, showing more or less imperfectly the character of the ornamentation; usually the spines are represented by stumps only or are almost completely obliterated. In these specimens the original form of the shell has been more or less considerably

[1] 'Trans. Geol. Soc.,' ser. 2, vol. iii (1832), p. 417, pl. xxxix, fig. 15; Goldfuss, 'Petref. Germ.,' vol. ii (1837), p. 221, pl. cxliv, fig. 7; Zittel, 'Bivalv. d. Gosaugeb.,' pt. i (1864), p. 37, pl. vi, fig. 1; Holzapfel, "Die Mollusk. Aachen. Kreide" ('Palæontographica,' vol. xxxv), p. 179, pl. xvii, figs. 1—5; G. Müller, 'Mollusk. d. Untersen. v. Braunschweig u. Ilsede' (1898), p. 63, pl. ix, figs. 13, 14.

[2] 'Pal. Franç. Terr. Crét.,' vol. iii (1844), p. 31, pl ccxlvii; Guéranger, 'Album Paléont. de la Sarthe' (1867), p. 15, pl. xx, figs. 8—10.

modified by pressure. On the other hand the shell in *C. proboscideum*, from Blackdown, is replaced by silica, so that both its ornamentation and original shape are perfectly preserved.

French examples were identified by d'Orbigny[1] with this species, for which he proposed the name *Cardium Moutonianum* since the specific name (*tuberculata*) under which Sowerby originally described the species had already been used. Sowerby, however, in the index at the end of vol. vi of the 'Mineral Conchology,' had already substituted *Gentianum* for the name which he originally used. I have not seen any specimen of *C. Moutonianum*, and am unable to say whether or not it is really identical with *C. Gentianum*, but in d'Orbigny's figures the difference in the sizes of the ribs and tubercles is seen on the anterior and posterior parts of the shell only.

C. Carolinum, d'Orbigny,[2] and *C. inæquicostatum*, Matheron,[3] are closely related to, and perhaps identical with, *C. proboscideum*.

Types.—*C. proboscideum*, from the Upper Greensand of Blackdown, and *Cardita tuberculata* (*Cardium Gentianum*), from the Upper Greensand of Devizes, are in the British Museum.

Distribution.—Upper Greensand (zone of *Schlœnbachia rostrata*) of Blackdown, Haldon, Devizes, and Ventnor.

Family—DICERATIDÆ, *Dall.*

Genus—TOUCASIA, *E. Munier-Chalmas*, 1873.

('Journ. de Conchyl.,' ser. 3, vol. xxi, p. 74. Douvillé, 'Bull. Soc. géol. de France,' ser. 3, vol. xv, 1887, p. 762.)

TOUCASIA LONSDALEI (*Sowerby*), 1836. Plate XXXIII, figs. 4—6.

1836. DICERAS LONSDALII, *J. de C. Sowerby*. Trans. Geol. Soc., ser. 2, vol. iv, pp. 268, 338, pl. xiii, fig. 4.
1850. CAPROTINA LONSDALII, *A. d'Orbigny*. Prodr. de Pal., vol. ii, p. 109 (*partim*).
1854. DICERAS LONSDALII, *J. Morris*. Cat. Brit. Foss., ed. 2, p. 201.
1855. REQUIENIA LONSDALEI, *S. P. Woodward*. Quart. Journ. Geol. Soc., vol. xi, p. 53, fig. 29.
1871. — LONSDALII, *F. Stoliczka*. Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 233.

[1] 'Pal. Franç. Terr. Crét.,' vol. iii (1844), p. 34, pl. ccxlviii; and 'Prodr. de Pal.,' vol. ii (1850), p. 162.

[2] Op. cit. (1844), p. 29, pl. ccxlv.

[3] 'Catal. Foss. des Bouches-du-Rhône' (1842), p. 157, pl. xviii, figs. 3, 4.

Remarks.—The examples of *Toucasia Lonsdalei* are in the condition of internal casts in a ferruginous sandstone, so that it is difficult to compare this with other species. The casts show a considerable amount of variation in form. D'Orbigny, de Loriol, and Pictet and Campiche included *Requienia carinata*, Matheron,[1] from the Urgonian of Orgon, as a synonym of Sowerby's *Diceras Lonsdalei*; but Prof. Douvillé[2] and M. Paquier[3] think that the identity of the two forms is doubtful and can only be determined by a careful comparison of English specimens with internal casts of *T. carinata*. Prof. Douvillé[4] suggests that there is a resemblance between *T. Seunesi* and *T. Lonsdalei*.

Type.—The type, which is stated to have come from near Calne, cannot now be found. The specimen from which Woodward's outline figure was drawn is in the British Museum, No. 88825.

Distribution.—Lower Greensand of Stock Orchard, south of Calne. Recorded by Morris from Lockswell Heath, south-west of Calne.

Family—MONOPLEURIDÆ, *Fischer.*

Genus—GYROPLEURA, *H. Douvillé*, 1887.

('Bull. Soc. géol. de France,' ser. 3, vol. xv, p. 768.)

GYROPLEURA CORNUCOPIÆ (*d'Orbigny*), 1847. Plate XXXIII, fig. 7 *a*, *b*.

1847.	CHAMA CORNUCOPIÆ,	*A. d'Orbigny.*	Pal. Franç. Terr. Crét., vol. iii, p. 689, pl. ccccIxiv, figs. 3—7.
1850.	— —	*d'Orbigny.*	Prodr. de Pal., vol. ii, p. 170.
1868.	— —	*F. J. Pictet and G. Campiche.*	Terr. Crét. de Ste. Croix (Matér. Pal. Suisse, ser. 5), p. 7.
1871.	— —	*F. Stoliczka.*	Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 234.
1887.	GYROPLEURA —	*H. Douvillé.*	Bull. Soc. géol. de France, ser. 3, vol. xv, p. 771, fig. 3.

Remarks.—Two specimens from the Chloritic Marl of Dorset agree in form with examples of *G. cornucopiæ* from the Cenomanian of Rouen (the locality

[1] 'Catal. Foss. des Bouches-du-Rhône' (1842), p. 104, pl. ii, figs. 1, 2; *Caprotina Lonsdalii*, d'Orbigny, 'Ann. Sci. Nat. Zool.,' ser. 2, vol. xvii (1842), p. 180; *Requienia Lonsdalii*, d'Orbigny, 'Pal. Franç. Terr. Crét.,' vol. iv (1850), p. 248, pls. dlxxvi, dlxxvii; *Caprotina Lonsdalii*, de Loriol, in Favre, 'Rech. géol. dans Savoie,' vol. i (1867), p. 386, pl. C, fig. 22; *Requienia Lonsdalii*, Pictet and Campiche, 'Terr. Crét. Ste. Croix' ('Mater. Pal. Suisse,' ser. 5, 1868), p. 14, pl. clxi.

[2] 'Bull. Soc. géol. de France,' ser. 3, vol. xvii (1889), p. 630.

[3] 'Les Rudistes Urgoniens,' I ('Mém. Soc. géol. de France,' Paléont. XI, 1903), p. 41.

[4] *Op. cit.*, p. 632.

of the type) and with d'Orbigny's figs. 4 and 5. The ornamentation in this species is imperfectly known; most of the examples from Rouen are either internal casts or have only portions of the shell present, on which the ornamentation is rather indistinct. In one specimen from Dorset part of the shell of the fixed valve is preserved; the radial ribs are not so prominent as in *G. inequirostrata*, but concentric lamellæ are distinct.

Distribution.—Chloritic Marl of Melbury Park and Chaldon, Dorset. Recorded by Jukes-Browne from the base of the Lower Chalk of Chard and Maiden Newton.

GYROPLEURA INEQUIROSTRATA (*Woodward*), 1833. Plate XXXIII, figs. 8—13.

1833. DICERAS INEQUIROSTRATUS, *S. Woodward.* Geol. Norfolk, p. 47, pl. v, fig. 22.
1854. CHAMA INÆQUIROSTRATA, *J. Morris.* Cat. Brit. Foss., ed. 2, p. 194.

Description.—Shell much inflated. Right valve large, oval, attached by a considerable portion of the anterior side; umbo prominent, pointed, incurved anteriorly. Left valve capuliform, with the umbo near the hinge-margin.

Ornamentation consists of strong, lamellar radial ribs, which are undulose where they cross growth-rings. The ribs have strongly serrate summits and are separated by rather broad, flat, smooth interspaces; sometimes the serrations are replaced by numerous transverse, scale-like structures. Near the fixed part of the right valve the ribs are more numerous than on the flank.

Measurements of fixed value:

	(1)	(2)	(3)	(4)
Length . .	22 .	19 .	16 .	14 mm.
Height . .	28 .	26 .	20 .	18 „

(1—4) Norwich.

Affinities.—*G. ciplyana* (de Ryckholt),[1] from Ciply, differs from this species in having the ribs more widely separated and in the presence of small ribs in the interspaces and on the sides of the main ribs. *G. russiensis* (d'Orbigny)[2] resembles closely *G. inequirostrata* and was regarded by Morris as a synonym of the latter, but it possesses small ribs on the sides of the main ribs.[3]

[1] 'Mélanges Paléont.,' pt. ii (1851), p. 179, pl. xii, figs. 12, 13; Douvillé, 'Bull. Soc. géol. de France,' ser. 3, vol. xv (1887), p. 744, pl. xxviii, fig. 11; Holzapfel, 'Mollusk. Aachen. Kreide' (1889), p. 189, pl. xix, figs. 5, 6; Wollemann, 'Fauna d. Lüneburg. Kreide' (1902), p. 75, pl. ii, figs. 5, 6.

[2] Murchison, de Verneuil, and de Keyserling, 'Géol. de la Russie,' vol. ii (1845), p. 496, pl. xliii, figs. 31—33; Douvillé, 'Bull. Soc. géol. de France,' ser. iii, vol. xv (1887), p. 775, pl. xxviii, fig. 13.

[3] *G. Münsteri* (v. Hagenow) is probably related to *G. inæquirostrata.* See Ravn, 'Mollusk. i Danmarks Kreidtafl. I, Lamellibr.' (1902), p. 126, pl. iv, figs. 10, 11.

Type.—From Norwich; in the British Museum.

Distribution.—Upper Chalk (zone of *Belemnitella mucronata*) of Norwich.

GYROPLEURA, sp. Plate XXXIV, fig. 1 *a—d.*

Description.—Right valve inflated, attached by a large portion of the dorsal surface. Left valve convex, subquadrate, with a pointed and incurved umbo. Right valve ornamented with numerous, small radial ribs which bear transverse nodes or scales. Left valve with relatively few, stout ribs bearing strong, somewhat irregular, transverse scales or lappet-like projections.

Affinities.—The ornamentation on the right valve is finer and that on the left valve coarser than in *G. cenomanensis* (d'Orbigny[1]); also the transverse ornamentation of the ribs is much coarser and less regular.[2]

Remarks.—The portion of the right valve which was attached includes the umbo and the neighbouring parts, whereas in most examples of *Gyropleura* only the part in front of the umbo is attached. The size of the area which was attached is larger than usual, but in other species it is seen that that area varies considerably in size in different examples.[3]

The only specimen seen was collected by Mr. Francis R. B. Williams.

Distribution.—Upper Chalk (zone of *Actinocamax quadratus*) near the groyne at Seaford.

Family—CORBULIDÆ, *Fleming.*

Genus—CORBULA, *J. G. Bruguière*, 1797.

('Encyc. Méth.,' Tabl. Vers., pl. 230.)

CORBULA ANGULATA (*Phillips*), 1829. Plate XXXIV, figs. 2—5.

1829. ISOCARDIA ANGULATA, *J. Phillips.* Geol. Yorks., p. 94, pl. ii, figs. 20, 21 (ed. 3, 1875, p. 252).

1841. — — *F. A. Römer.* Die Verstein. d. nord-deutsch. Kreidegeb., p. 70.

1854. — — *J. Morris.* Cat. Brit. Foss., ed. 2, p. 204.

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[1] 'Pal. Franç. Terr. Crét.,' vol. iv (1850), p. 261, pl. dxcv, figs. 1—4.

[2] Douvillé, 'Bull. Soc. géol. de France,' ser. 3, vol. xv (1887), p. 771, pl. xxviii, fig. 7.

[3] In a specimen figured by Griepenkerl the surface of attachment is unusually large; 'Senon v. Königslutter' ('Palæont. Abhandl.,' v, 1889), pl. vii, fig. 3.

1865. Isocardia? angulata, *F. J. Pictet and G. Campiche.* Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 240.
1871. Isocardia angulata, *F. Stoliczka.* Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 194.
1877. Isocardia? angulata, *G. Böhm.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xxix, p. 241.
1889. Isocardia angulata, *G. W. Lamplugh.* Quart. Journ. Geol. Soc., vol. xlv, p. 616.
1900. — — *A. Wollemann.* Die Biv. u. Gastrop. d. deutsch. u. holländ. Neocoms (Abhandl. d. k. preussisch. geol. Land., N. F., pt. 31), p. 114.
1905. Corbula (Isocardia) angulata, *E. Harbort.* Fauna d. Schaumberg-Lippeschen Kreidemulde (Ibid., pt. 45), p. 81.
1906. Isocardia angulata, *A. Wollemann.* Die Biv. u. Gastrop. nord-deutsch. Gaults (Jahrb. d. k. preussisch. geol. Land., für 1906, vol. xxvii), p. 277.

Description.—Shell with sub-quadrate outline, rounded, occasionally subtriangular, very convex, equivalve, more or less considerably inequilateral; length greater than height. Anterior part produced, rounded; ventral margin slightly curved; posterior margin truncate, slightly convex, somewhat oblique, forming angles with the ventral and dorsal margins. Postero-dorsal margin sloping ventrally. Umbones moderately large, curved inward and more or less considerably forward, with a carina extending to the postero-ventral angle, cutting off a large, flattened postero-dorsal area. The part of the valve in front of the carina is regularly convex. Lunular region depressed.

Ornamentation consists of fine concentric striæ.

Measurements:

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	
Length	7·1	6·8	6·2	6	6·0	5·0	4·5	mm.
Height	6·0	5·5	5·0	5	4·5	4·1	4·0	,,

(1—7) Speeton.

Affinities.—This species shows some resemblance to *C. gaultina* (see p. 214), but is more nearly quadrate in outline, relatively longer, of larger size, and without distinct ribs.

C. angulata is fairly common in the Speeton Clay, but no specimen showing the hinge appears to have been found, so that the generic position assigned to this species by Phillips was presumably based on the external character of the shell. Pictet and Campiche thought that it probably belonged to *Cyprina.* Wollemann states that it is most likely a *Corbula*, and Harbort, who has seen the hinge,

definitely refers it to that genus; if this view of its position is confirmed it will be necessary to substitute a new name, since *angulata* had been previously used by Lamarck for a species of *Corbula* from the Eocene.

Distribution.—Speeton Clay (zones of *Belemnites jaculum* and *B. brunsvicensis*) of Speeton.[1]

CORBULA STRIATULA, *Sowerby*, 1827. Plate XXXIV, figs. 6—12.

1827. CORBULA STRIATULA, *J. de C. Sowerby.* Min. Conch., vol. vi, p. 139, pl. dlxxii, figs. 2, 3.
1846. — — *A. d'Orbigny.* Pal. Franç. Terr. Crét., vol. iii, p. 459, pl. ccclxxxviii, figs. 9—13.
1850. — — *A. d'Orbigny.* Prodr. de Pal., vol. ii, p. 118.
1854. — — *J. Morris.* Cat. Brit. Foss., ed. 2, p. 196.
1858. — — *F. J. Pictet and E. Renevier.* Foss. Terr. Aptien (Matér. Pal. Suisse, ser. 1), p. 176.
1864. — — *F. J. Pictet and G. Campiche.* Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 36.
1870. — — *F. Stoliczka.* Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 40.
1895. — — *G. Maas.* Zeitschr. der deutsch. geol. Gesellsch., vol. xlvii, p. 257.
— — LÆVIS, *Maas.* Ibid., p. 257.
1900. — STRIATULA, *A. Wollemann.* Die Biv. u. Gastrop. d. deutsch. u. holländ. Neocoms (Abhandl. d. k. preussisch. geol. Land., N. F., pt. 31), p. 144.

Non 1840. — — *A. Goldfuss.* Petref. Germ., vol. ii, p. 251, pl. cli, fig. 16 (*C. substriatula*, d'Orbigny, 1850).
— 1847. — — *J. Müller.* Petref. der Aachen. Kreidef., pt. i, p. 25, pl. ii, fig. 8.
— 1854. — — *A. d'Archiac.* Bull. Soc. géol. de France, ser. 2, vol. xi, p. 209, pl. iv, figs. 14, 15.
— 1858. — — *J. Vilanova-y-Piera.* Mem. geog.-agric. de Castellon, pl. iii, fig. 14.
— 1867. — — *O. Fraas.* Aus dem Orient, p. 92.
— 1870. — — *H. Credner.* Zeitschr. der deutsch. geol. Gesellsch., vol. xxii, p. 236.

[1] The type of *Corbula punctum*, Phillips, from Speeton, cannot be found, and I have not seen any specimen which could be satisfactorily identified with that species. Phillips, 'Geol. Yorks.' (1829), p. 122, pl. ii, fig. 6.

Non 1885.	CORBULAMELLA STRIATULA, *J. Böhm.*		Verhandl. d. nat. Vereines d. preuss. Rheinl., vol. xlii, p. 144.
— 1887.	— —	*F. Frech.*	Zeitschr. d. deutsch. geol. Gesellsch., vol. xxxix, p. 173, pl. xii, figs. 5—8.
— 1888.	— —	*G. Müller.*	Jahrb. d. k. preussisch. geol. Land., für 1887, p. 436.
1889.	CORBULA STRIATULA, *O. Griepenkerl.*		Senon. v. Königslutter (Palæont. Abhandl., vol. iv), p. 69.
1897.	— —	*A. Fritsch.*	Stud. im Gebiete der böhm. Kreideformat., vi, Chlomek. Schicht., p. 64, fig. 83.
— 1901.	CORBULAMELLA STRIATULA, *F. Sturm.*		Jahrb. d. k. preussisch. geol. Land., für 1900, vol. xxi, p. 88.

Description.—Shell ovate, usually much inflated, produced and pointed posteriorly, inequilateral, slightly inequivalve. Anterior and ventral margins rounded. Posterior margin short, obliquely truncated. Umbones broad, strongly incurved, with a carina extending to the postero-ventral angle and cutting off a flattened postero-dorsal area. Ornamentation consists of numerous concentric ribs which extend on to the postero-dorsal area, where they are narrower and more distinct.

Measurements:

	(1)	(2)	(3)
Length	6·7	6·0	5·5 mm.
Height	5·0	4·2	4·0 „

(1) Atherfield Beds, East Shalford; (2, 3) Crackers, Atherfield.

Affinities.—This species is distinguished from *C. neocomiensis*, d'Orbigny,[1] by the smaller and more pointed posterior end. It differs from *C. substriatula* in being less inequivalve and in possessing a distinct carina. Wollemann considers that *C. lævis*, Maas, is identical with *C. striatula.* Another form which appears to be closely allied is *C. neverisensis*, de Loriol,[2] from the Gault of Cosne.

Remarks.—This species varies considerably in convexity and in relative length and height. The shorter, more globose, and more distinctly rostrate forms agree with the type. The more elongate and less convex forms are not so numerous, and although differing considerably in shape from the globose forms, yet they agree with them in other respects and do not appear to be specifically distinct.

Specimens from the Lower Greensand of Punfield resemble *C. striatula*, but possess stronger concentric ribs—in some cases, as in the example figured (Plate XXXIV, fig. 13), the ribs are considerably stronger, but in others the difference is not so great.

1 'Pal. Franç. Terr. Crét.,' vol. iii (1846), p. 457, pl. ccclxxxviii, figs. 3—5, and 'Prodr. de Pal.,' vol. ii (1850), p. 76.

2 'Gault de Cosne' (1882), p. 43, pl. v, figs. 23—25.

Type.—Internal casts from the Hythe Beds of Pulborough, in the British Museum.

Distribution.—Lower Greensand: Crackers of Atherfield. Recorded by Fitton from the *Perna*-bed, Atherfield Clay, and Beds VI—IX, XIII, XIV near Atherfield. Ferruginous Sands of Shanklin. Atherfield Beds of Peasmarsh, East Shalford and Sevenoaks. Hythe Beds of Pulborough. Folkestone Beds of Folkestone.

CORBULA GAULTINA, *Pictet and Campiche*, 1864. Plate XXXIV, figs. 14—16.

1864. CORBULA GAULTINA, *F. J. Pictet and G. Campiche.* Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 4), p. 34, pl. c, figs. 3, 4.
1870. — — *F. Stoliczka.* Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 40.

Description.—Shell subtriangular, rounded, inflated, slightly inequivalve, a little longer than high, moderately inequilateral. Anterior margin rounded. Posterior margin subtruncate, oblique. Umbones prominent, rather high, curved forward, with an inconspicuous carina cutting off a concave postero-dorsal area. Ornamentation consists of small, concentric ribs.

Measurements:

	(1)	(2)	(3)	(4)
Length .	5·5 .	5·0 .	4·6 .	4·0 mm.
Height .	5·0 .	4·5 .	4·0 .	3·6 „

(1—4) Gault, Folkestone.

Affinities.—In this species the shell is relatively shorter and more inflated than in *C. elegantula*, d'Orbigny.[1]

C. gaultina may perhaps be, as was pointed out by Pictet and Campiche, identical with *C. socialis*, d'Orbigny,[2] of which no sufficient diagnosis has been given.

Remarks.—Numerous individuals of this species are found close together in groups. When the surface of the shell is not perfectly preserved the ribs become indistinct.

Type.—From the Gault of Folkestone.

Distribution.—Lower Gault (Bed 2) of Folkestone.

[1] 'Pal. Franç. Terr. Crét.,' vol. iii (1846), p. 460, pl. ccclxxxviii, figs. 14—17.

[2] 'Prodr. de Pal.,' vol. ii (1850), p. 136.

Corbula truncata, *Sowerby*, 1836. Plate XXXIV, figs. 17—22.

1836. Corbula truncata, *J. de C. Sowerby.* Trans. Geol. Soc., ser. 2, vol. iv, pp. 240, 341, pl. xvi, fig. 8.
1850. — — *A. d'Orbigny.* Prodr. de Pal., vol. ii, p. 160.
1854. — — *J. Morris.* Cat. Brit. Foss., ed. 2, p. 196.
1868. — — *A. Briart and F. L. Cornet.* Meule de Bracquegnies (Mém. cour. et Mém. des Sav. étrangers, vol. xxxiv), p. 81, pl. vi, figs. 13—15.
1870. — — *F. Stoliczka.* Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 40.
(?) 1895. — cf. — *E. Tiessen.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xlvii, p. 485.

Non 1846. — — *A. d'Orbigny.* Pal. Franç. Terr. Crét., vol. iii, p. 461, pl. ccclxxxviii, figs. 18—20 (? *C. Goldfussiana*, Matheron).

Description.—Shell subquadrate or subtriangular, elongate, rounded, moderately convex, inequilateral, slightly inequivalve, considerably longer than high. Anterior margin well rounded. Ventral margin slightly convex, its posterior part bending upwards. Posterior margin obliquely truncated, forming an acute angle with the ventral margin and an obtuse angle with the dorsal margin. Umbones broad, with a carina extending to the postero-ventral angle and cutting off a flattened or concave postero-dorsal area. Ornamentation consists of numerous fine, concentric ribs which are continued on to the postero-dorsal area.

Measurements :

	(1)	(2)	(3)	(4)
Length . . .	9	8·5	8	7·5 mm.
Height . . .	6·5	6	5·75	5 „

(1—4) Blackdown.

Affinities.—This species is less elongate than *C. truncata*, d'Orbigny, and is also distinguished by its concentric ornamentation. It differs from *C. lineata*, Müller,[1] in the greater obliquity of the posterior margin and in the more numerous concentric ribs.

Type.—From Blackdown, in the Bristol Museum.

Distribution.—Upper Greensand (zone of *Schlœnbachia rostrata*) of Blackdown.

[1] Holzapfel, "Die Mollusk. Aachen. Kreide" ('Palæontographica,' vol. xxxv, 1889), p. 146, pl. x, figs. 16—19.

Corbula elegans, *Sowerby*, 1827. Plate XXXIV, figs. 23—28.

1827.	Corbula elegans,		*J. de C. Sowerby.* Min. Conch., vol. vi, p. 139, pl. dlxxii, fig. 1.
1850.	—	—	*A. d'Orbigny.* Prodr. de Pal., vol. ii, p. 160.
1854.	—	—	*J. Morris.* Cat. Brit. Foss., ed. 2, p. 195.
? 1867.	—	—	?, *E. Guéranger.* Album Paléont. de la Sarthe, p. 12, pl. xvi, fig. 1.
1870.	—	—	*F. Stoliczka.* Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 40.
Non 1846.	—	—	*A. d'Orbigny.* Pal. Franç. Terr. Crét., vol. iii, p. 460, pl. ccclxxxviii, figs. 14—17 (*C. elegantula*, d'Orbigny, 1850).
? — 1847.	—	—	?, *A. d'Archiac.* Mém. Soc. géol. de France, ser. 2, vol. ii, p. 302.

Description.—Shell subtrigonal, rounded, very convex, inequivalve, inequilateral, a little longer than high.

Right valve with the anterior part sloping rapidly to the margin; anterior margin rounded; ventral margin convex, its posterior part curving upwards. Posterior part produced, compressed, separated from the sides by a groove passing from the umbo to the postero-ventral angle; on the dorsal side of the groove is a small carina. Posterior margin truncated, forming approximately a right angle with the straight postero-dorsal margin. Umbo prominent, sharp, curved considerably inward and somewhat forward. Ornamentation consists of strong, broad, concentric ribs separated by narrow grooves, except on the postero-dorsal area, which is nearly smooth.

Left valve smaller, less convex, and with smaller ribs than the right valve. Postero-dorsal area separated from the side of the valve by a groove or sharp carina.

Measurements :

	(1)	(2)	(3)	(4)
Length . . .	6	5·5	5	4·5 mm.
Height . . .	4·75	4·5	4	3·6 ,,

(1—4) Blackdown.

Affinities.—This species is distinguished from *C. elegantula*, d'Orbigny, by its broader concentric ribs and rostrate posterior end. It is less globose, less pointed posteriorly, and has stronger ribs than *C. substriatula*, d'Orbigny.

Type.—From Blackdown, in the British Museum.

Distribution.—Upper Greensand (zone of *Schlœnbachia rostrata*) of Blackdown and Haldon. Recorded by Price from the Upper and Lower Gault of Folkestone.

PLATE XXVIII.

Genus—Dosiniopsis, *Conrad.*

Figs.

1—6. *D. subrotunda* (Sow.). Upper Greensand, Blackdown. Sedgwick Museum, Cambridge; except fig. 2, British Museum, No. L17067. (P. 181).

1, 2, 6. Right valves.
3. Interior of right valve × $1\frac{1}{2}$.
4, 5. Left valves. 5 *b*, interior of 5 *a*.

7—10. *D. caperata* (Sow.). Upper Greensand, Blackdown. Sedgwick Museum. (P. 182).

7, 8. Right valves. 7 *b*, hinge × $1\frac{1}{2}$.
9, 10. Left valves. 10 *b*, interior of 10 *a*; 10 *c*, dorsal view.

Genus—Cyprimeria, *Conrad.*

11—18. *C.* (*Cyclorisma*) *vectensis* (Forbes). Lower Greensand (Crackers), Atherfield. Sedgwick Museum. (P. 183.)

11, 12. Right valves. 11 *b*, dorsal view of 11 *a*.
13, 14. Hinges of right valves. 13, a small specimen × 2.
15, 16. Left valves.
17. Hinge of left valve × $1\frac{1}{2}$.
18. Internal cast of right valve. Exact horizon not known.

19—23. *C.* (*Cyclorisma*) *parva* (Sow.). Lower Greensand (Crackers), Atherfield. Sedgwick Museum. (P. 184.)

19 *a*, right valve; *b*, dorsal view of both valves.
20. Hinge of right valve × 3.
21—23. Left valves. 21 *b*, part of 21 *a* near the ventral margin × 4.

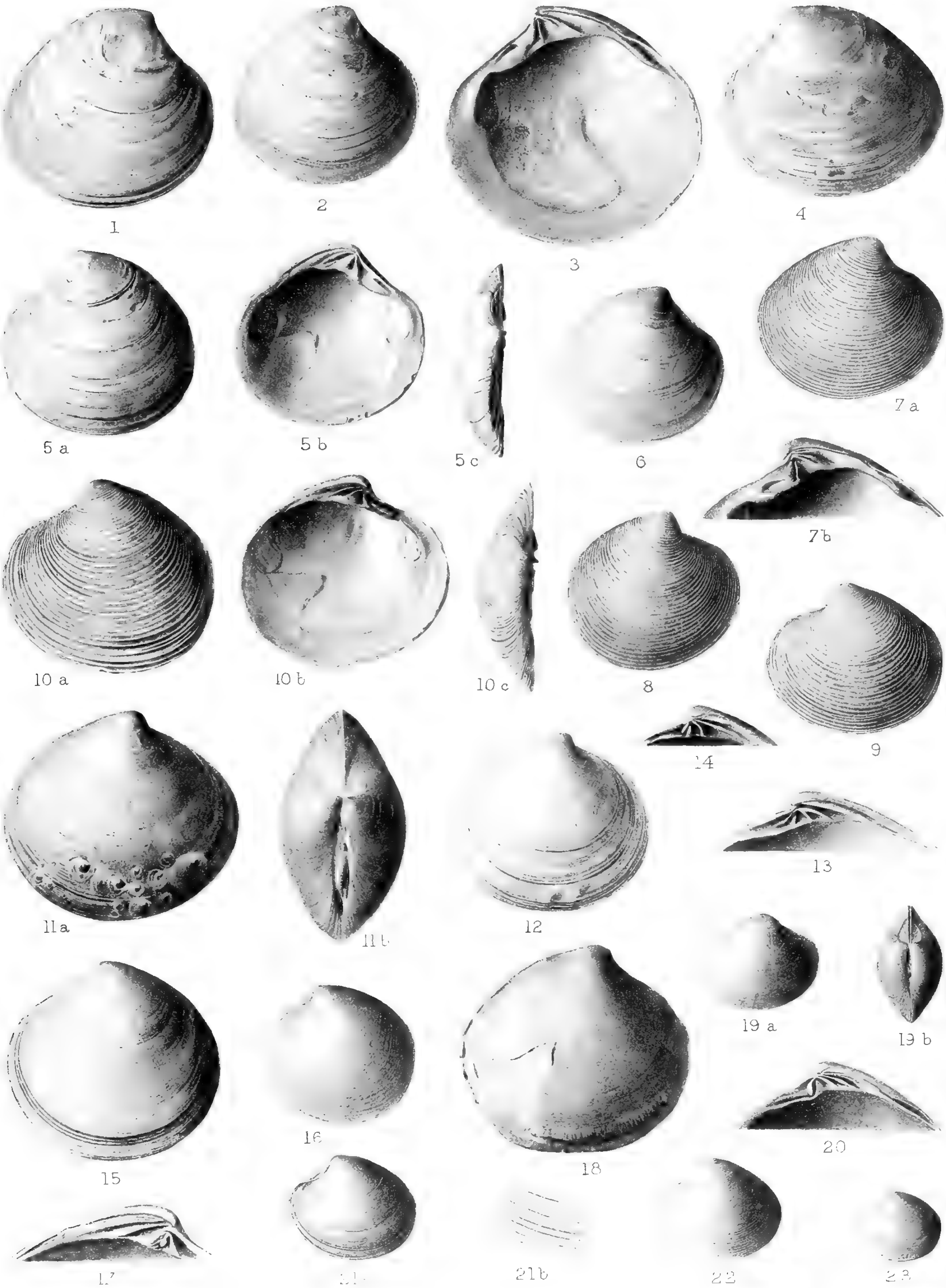

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PLATE XXIX.

CYPRIMERIA (*continued*).

FIGS.

1—3. *C.* (*Cyclorisma*) *parva* (Sow.). Lower Greensand (Crackers), Atherfield, except fig. 3. Sedgwick Museum, Cambridge. (P. 184.)

1 *a*, left valve; *b*, anterior view of the same specimen.
2. Hinge of left valve × 3.
3. *Perna*-bed, East Shalford. Internal cast of left valve.

4—6. *C.* (*Cyclorisma*) *rotomagensis* (d'Orb.). 4, 5, Chloritic Marl. (P. 186.)

4. Woolcombe. Museum of Practical Geology, No. 18735. Right valve, with part of the shell preserved.
5. Maiden Bradley. Museum of Practical Geology, No. 18746. *a*, internal cast of right valve; *b*, dorsal view of the same specimen.
6. Cenomanian, Rouen. M. Fortin's Collection. Left valve with shell preserved.

7—15. *C.* (*Cyclorisma*) *faba* (Sow.). Upper Greensand, Blackdown. Sedgwick Museum, except figs. 11, 14, 15. (P. 187.)

7—9. Right valves.
10. Hinge of right valve × 2.
11. Left valve. Museum of Practical Geology, No. 19774.
12. Dorsal view of both valves.
13. Hinge of left valve × $1\frac{1}{2}$.
14. The Type of *Venus sublævis*, Sow. Bristol Museum. (P. 189.)
15. The Type of *Venus immersa*, Sow., somewhat crushed. Bristol Museum.

Genus—CLEMENTIA, *Gray*.

16—18. *C.* (*Flaventia*) *Ricordeana* (d'Orb.). Lower Greensand (*Perna*-bed), Atherfield. Sedgwick Museum. 16, 17, right valves; 18 *a*, left valve; *b*, dorsal view of the same specimen—the lunule is drawn from another specimen. (P. 189.)

19—26. *C.* (*Flaventia*) *ovalis* (Sow.). Upper Greensand, Blackdown. Sedgwick Museum, Cambridge, except figs. 20, 23, 26. (P. 191.)

19—22. Right valves. 20, Museum of Practical Geology, No. 19778.
23. British Museum, No. L19444. Interior of right valve.
24. Hinge of right valve × $1\frac{1}{2}$.
25 *a*, left valve; *b*, dorsal view of the same specimen.
26. Museum of Practical Geology, No. 19814. Hinge of left valve × $1\frac{1}{2}$.

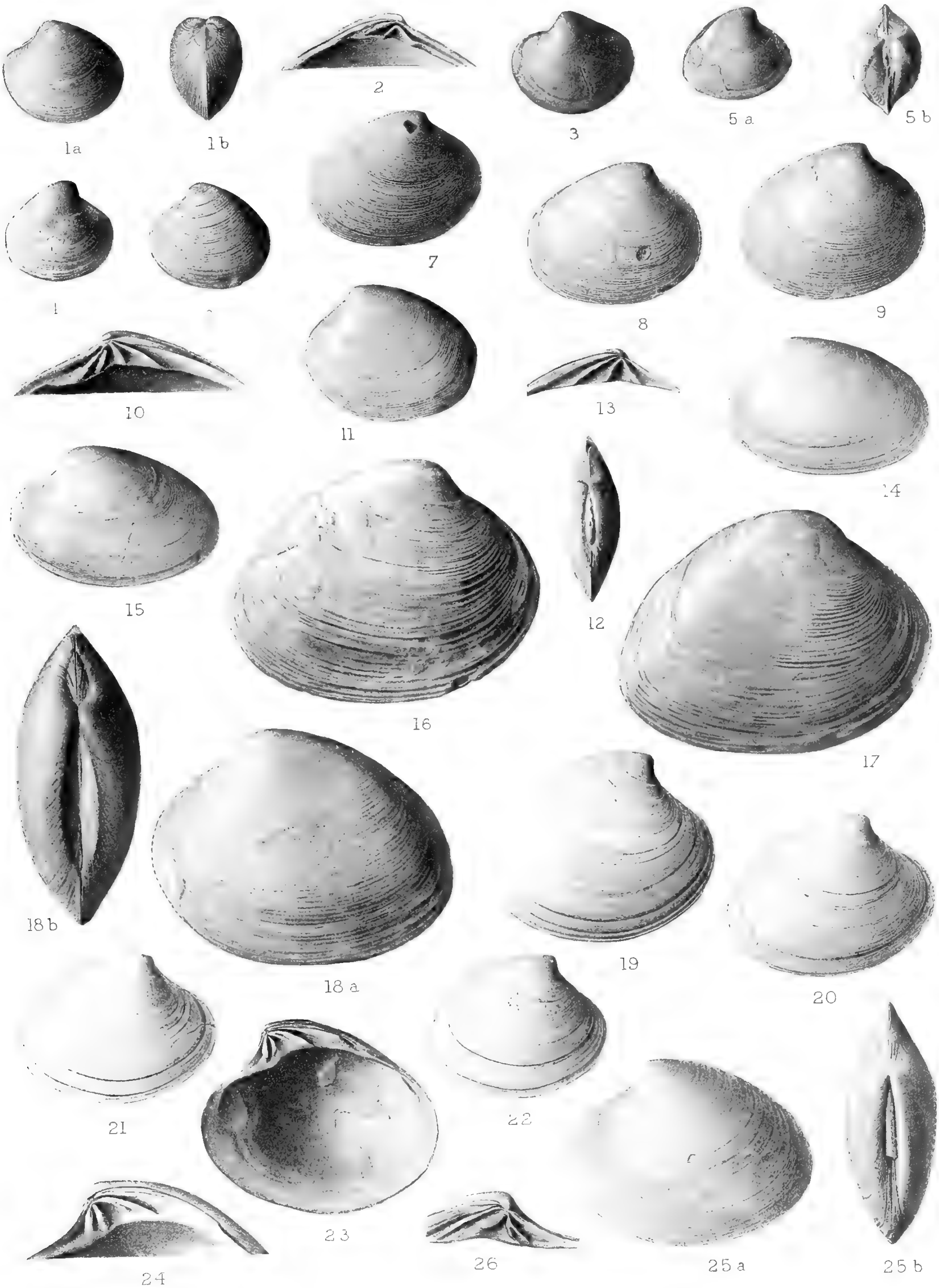

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PLATE XXX.

Genus—CALLISTA, *Mörch.*

FIGS.

1—6. *C. plana* (Sow.). Upper Greensand, Blackdown. Sedgwick Museum, Cambridge. (P. 192.)

1 *a*, right valve; *b*, ornamentation on the postero-ventral part × 6.

2. Hinge of right valve. The part anterior to the middle of the anterior pit is drawn from another specimen.

3—6. Left valves. 3 *b*, interior of 3 *a*; 3 *c*, dorsal view of 3 *a*; 4 *b*, anterior view of 4 *a*.

Genus—PROTOCARDIA, *Beyrich.*

7. *P. anglica*, Woods. Lower Greensand (Crackers), Atherfield. Sedgwick Museum. *a*, left valve × $\frac{2}{3}$; *b*, dorsal view × 1. (P. 194.)

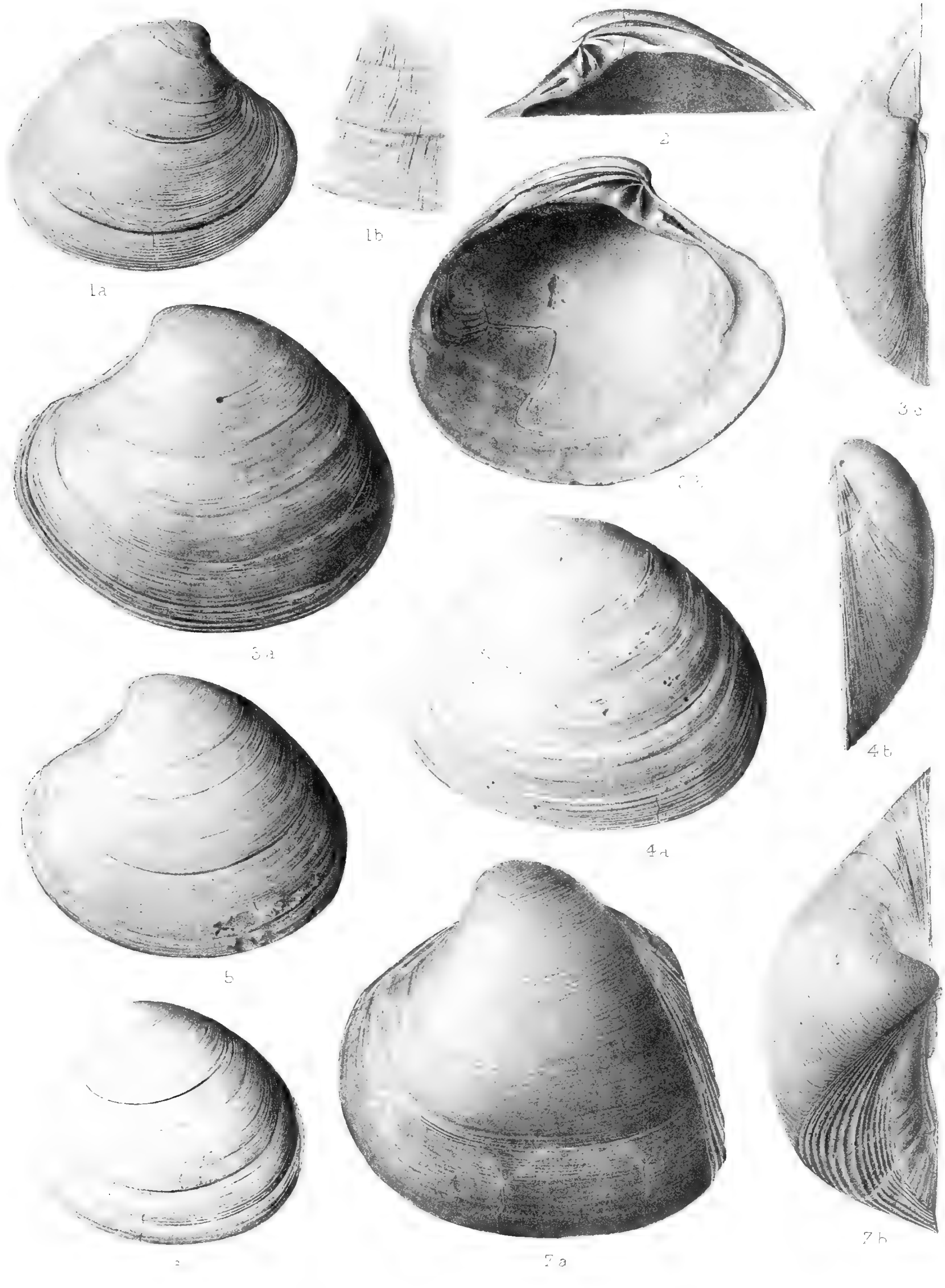

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PLATE XXXI.

Protocardia (*continued*).

Figs.

1. *P. anglica*, Woods. Lower Greensand (Crackers), Atherfield. Sedgwick Museum, Cambridge. Right valve. (P. 194.)

2, 3. *P. sphæroidea* (Forbes). Lower Greensand (*Perna*-bed). (P. 195.)

2. Sandown. British Museum, No. L8247. *a*, left valve; *b*, dorsal view of the same specimen. $\times \frac{4}{5}$.
3. Atherfield. York Museum. *a*, left valve; *b*, posterior view of the same. $\times \frac{4}{5}$.

4. *P.* sp. Upper Greensand, Haldon. British Museum, No. L17041. Right valve. (P. 196.)

5. *P.* sp. Speeton Clay (zone of *Belemnites lateralis*), Speeton. Mr. Lamplugh's Collection. *a*, right valve $\times$ 2; *b*, dorsal view of both valves $\times$ 2. (P. 197.)

6. *P. Hillana* (Sow.). Upper Greensand, Blackdown. Sedgwick Museum. *a*, left valve; *b*, posterior view of *a*; *c*, part of the posterior area $\times$ 4. (P. 197.)

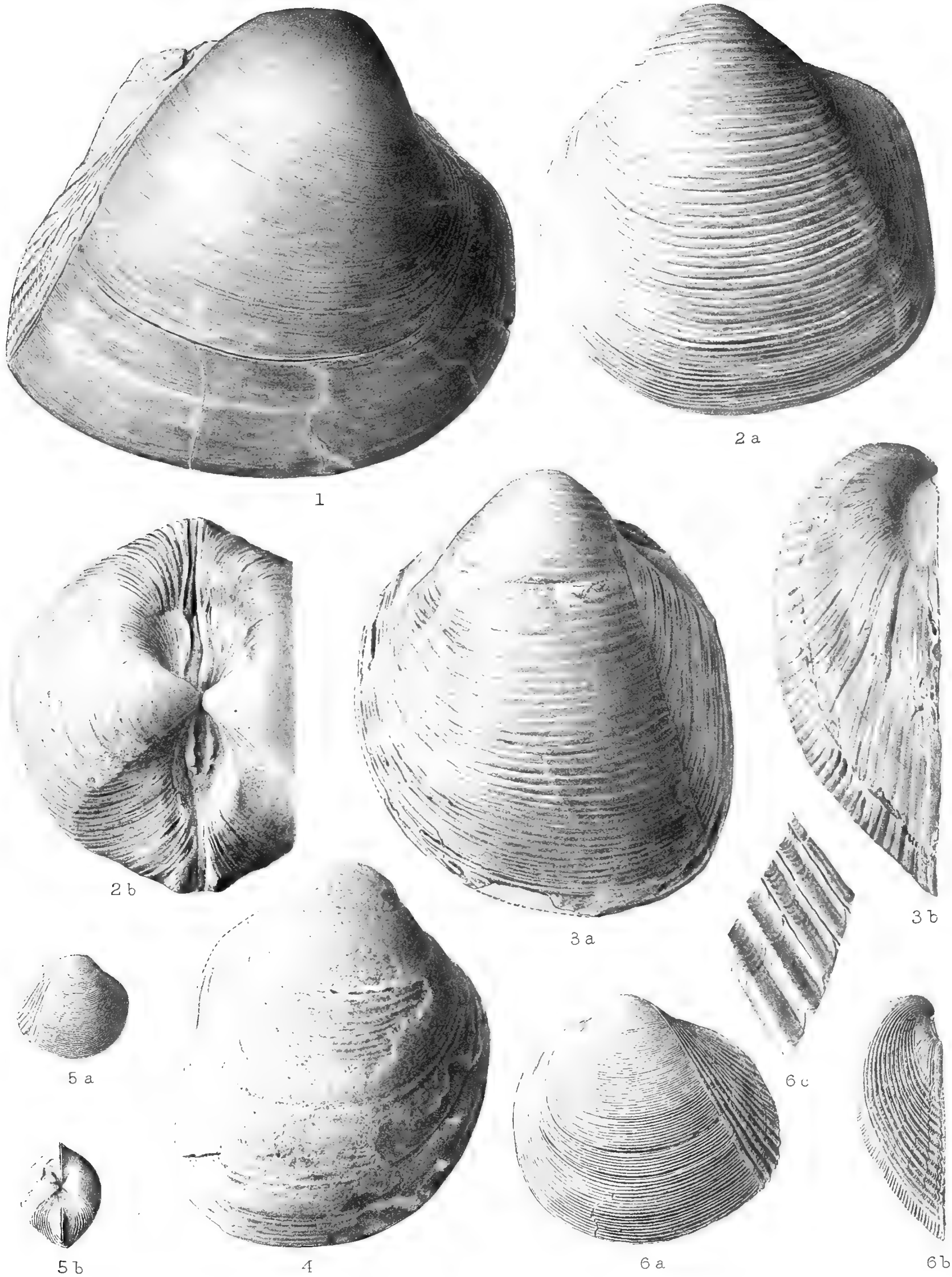

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PLATE XXXII.

Protocardia (*continued*).

Figs.

1—6. *P. Hillana* (Sow.). Upper Greensand, Blackdown. Sedgwick Museum, Cambridge. (P. 197.)

1. Left valve.
2, 3. Right valves.
4. Interior of left valve.
5. Hinge of right valve.
6. Dorsal view of both valves.

Genus—Cardium, *Linnæus.*

7—10. *C. Ibbetsoni*, Forbes. Lower Greensand (Crackers), Atherfield. Sedgwick Museum, Cambridge. (P. 201.)

7 *a*, right valve; *b*, dorsal view of both valves; *c*, posterior view; *d*, anterior view; *e*, portion of ornamentation of posterior area × 4; *f*, ornamentation near the middle of the ventral border × 4.
8, 9. Right valves.
10. Left valve.

11. *C. Cottaldinum*, d'Orb. Lower Greensand, Upware. Sedgwick Museum. *a*, right valve; *b*, dorsal view of both valves; *c*, posterior view; *d*, ornamentation of posterior area × 4; *e*, ornamentation near the mid-ventral border × 4. (P. 203.)

12. *C.* sp. Lower Greensand, Seend. Museum of Practical Geology, No. 21273. *a*, right valve; *b*, dorsal view. (P. 204.)

13—15. *C. turoniense*, Woods. Chalk Rock, Cuckhamsley. Sedgwick Museum. (P. 204.)

13 *a*, internal cast of right valve × $1\frac{1}{2}$; *b*, anterior view of the same × $1\frac{1}{2}$.
14. Internal cast of left valve × $1\frac{1}{2}$.
15. Ornamentation drawn from a wax mould of an external cast × 6.

16. *C.* sp. Chalk Rock, Cuckhamsley. Sedgwick Museum. Internal cast. *a*, right valve; *b*, dorsal view of both valves. (P. 205.)

17. *C.* sp. Upper Chalk (zone of *Belemnitella mucronata*), Norwich. British Museum, No. L19443. Internal cast. *a*, left valve; *b*, dorsal view of both valves; *c*, posterior view. (P. 205.)

18, 19. *C.* (*Granocardium*) *proboscideum*, Sow. Upper Greensand, Blackdown. Sedgwick Museum. (P. 205.)

18. Right valve. The anterior marginal part is drawn from another specimen.
19. Left valve. Dorsal part decorticated.

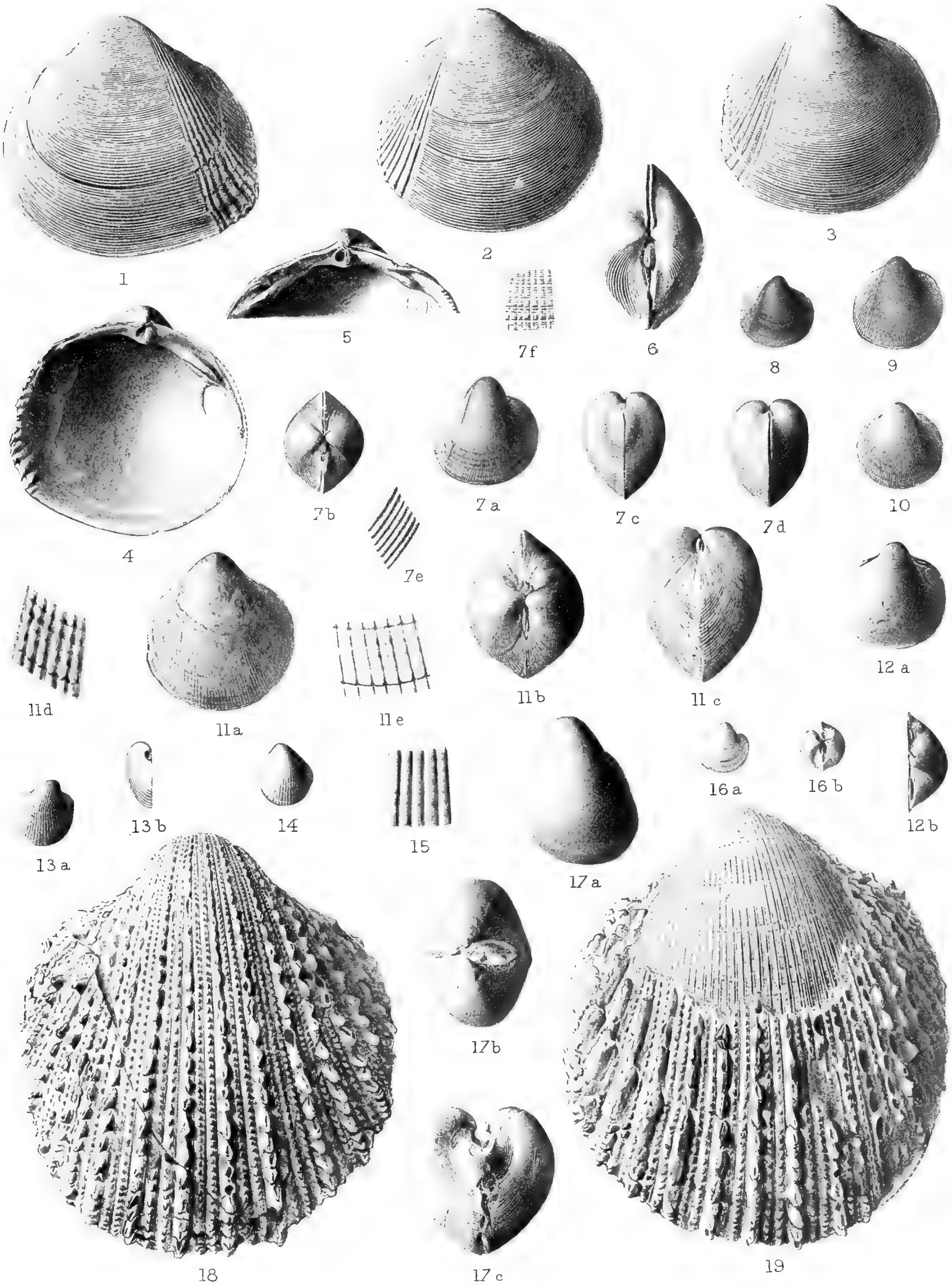

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PLATE XXXIII.

CARDIUM (*continued*).

FIGS.

1—3. *C.* (*Granocardium*) *proboscideum*, Sow. Upper Greensand, Blackdown. Sedgwick Museum, Cambridge. (P. 205.)

1 *a*, right valve; *b*, anterior view of the same.
2 *a*, interior of left valve; *b*, dorsal view of the same.
3. Hinge of right valve.

Genus—TOUCASIA, *Munier-Chalmas.*

4—6. *T. Lonsdalei* (Sow.). Lower Greensand, Stock Orchard, near Calne. Internal casts. (P. 207.)

4. Both valves. Museum of Practical Geology, No. 22720.
5. Lower valve. Museum of Practical Geology, No. 22721. × $\frac{4}{5}$.
6. Upper valve. British Museum, No. 88825.

Genus—GYROPLEURA, *Douvillé.*

7. *G. cornucopiæ* (d'Orb.). Chloritic Marl, Melbury Park. Museum of Practical Geology, No. 22440. *a*, right valve; *b*, posterior view of both valves. (P. 208.)

8—13. *G. inequirostrata* (Woodw.). Upper Chalk (zone of *Belemnitella mucronata*), Norwich. 8—10, British Museum, No. 21002. 11—13, Norwich Museum. (P. 209.)

8 *a*, right valve; *b*, posterior view of both valves; *c*, ornamentation of right valve × 8.
9 *a*, left valve and umbo of right valve; *b*, posterior view of both valves.
10. Ornamentation of right valve near the ventral margin × 12.
11. Right valve. Internal cast.
12. Anterior view of both valves. Internal cast.
13 *a*, left valve and umbo of right valve; *b*, posterior view of both valves Internal cast.

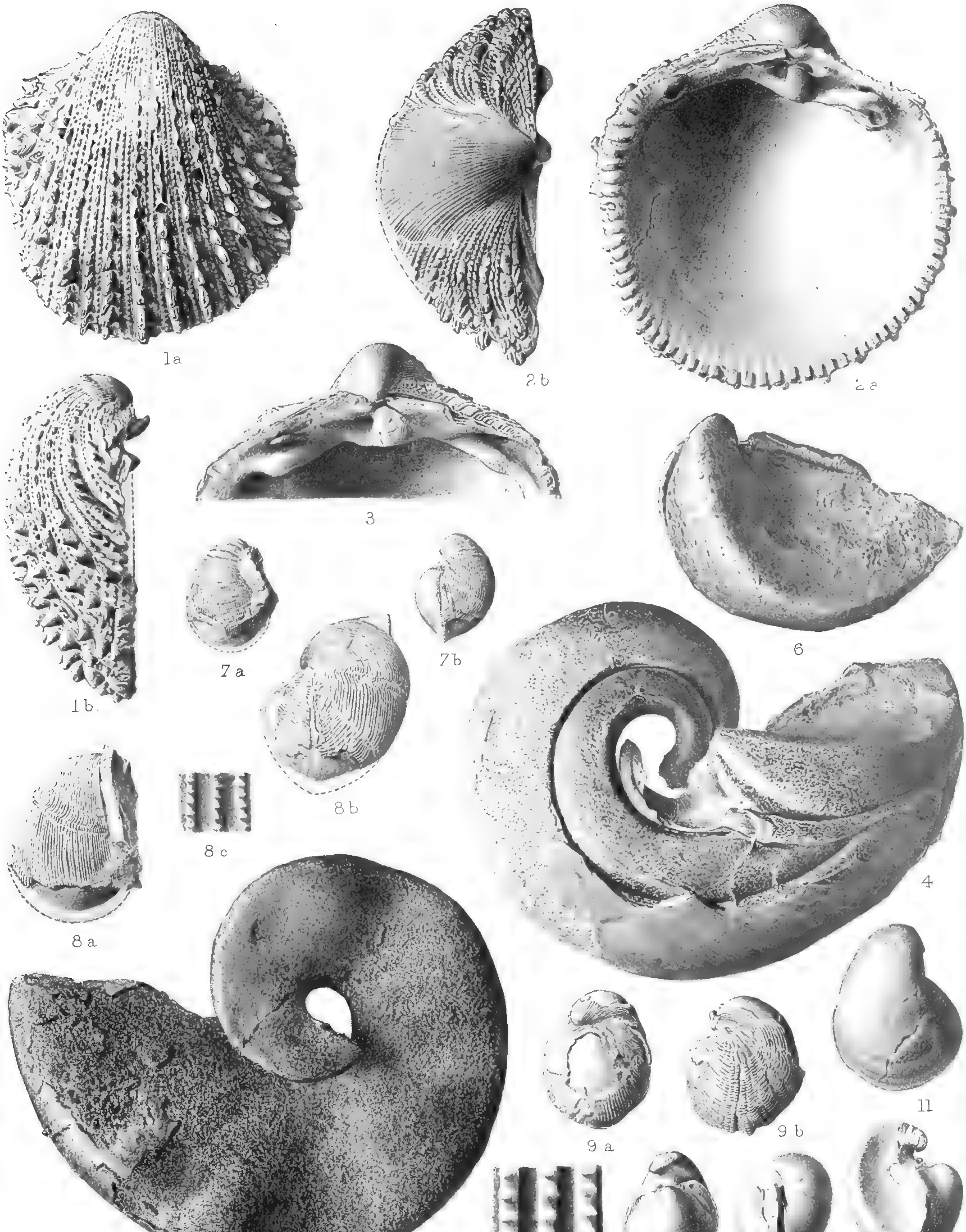

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PLATE XXXIV.

Gyropleura (*continued*).

Figs.

1. *G.* sp. Upper Chalk (zone of *Actinocamax plenus*), Seaford. Mr. F. R. B. Williams' Collection. *a*, left valve and umbonal part of right valve; *b*, posterior view of both valves; *c*, ornamentation of left valve × 3; *d*, ornamentation of right valve × 3. (P. 210.)

Genus—Corbula, *Bruguière.*

2—5. *C. angulata* (Phill.). Speeton Clay, Speeton. 2, 5, Sedgwick Museum; 3, 4, Mr. Lamplugh's Collection. (P. 210.)

2 *a*, left valve; *b*, dorsal view of both valves; *c*, anterior view. × 5.
3, 4. Left valves × 5.
5. Right valve × 5.

6—12. *C. striatula*, Sow. Lower Greensand (Atherfield Beds), East Shalford; except 7 and 12, from the Crackers, Atherfield. Sedgwick Museum. × 5. (P. 212.)

6—10. Right valves. 9 *b*, dorsal view of 9 *a*.
11 *a*, left valve; *b*, dorsal view of both valves.
12. Anterior view of both valves.

13. *C.* sp. Lower Greensand, Punfield. Museum of Practical Geology, No. 22723. Right valve, the posterior part broken, × 5. (P. 213.)

14—16. *C. gaultina*, Pict. and Camp. Gault, Folkestone. × 5. (P. 214.)

14. Sedgwick Museum. *a*, right valve; *b*, dorsal view of both valves; *c*, anterior view.
15, 16. Museum of Practical Geology, Nos. 22727, 22728. Left valves.

17—22. *C. truncata*, Sow. Upper Greensand, Blackdown. Sedgwick Museum. × 5. (P. 215.)

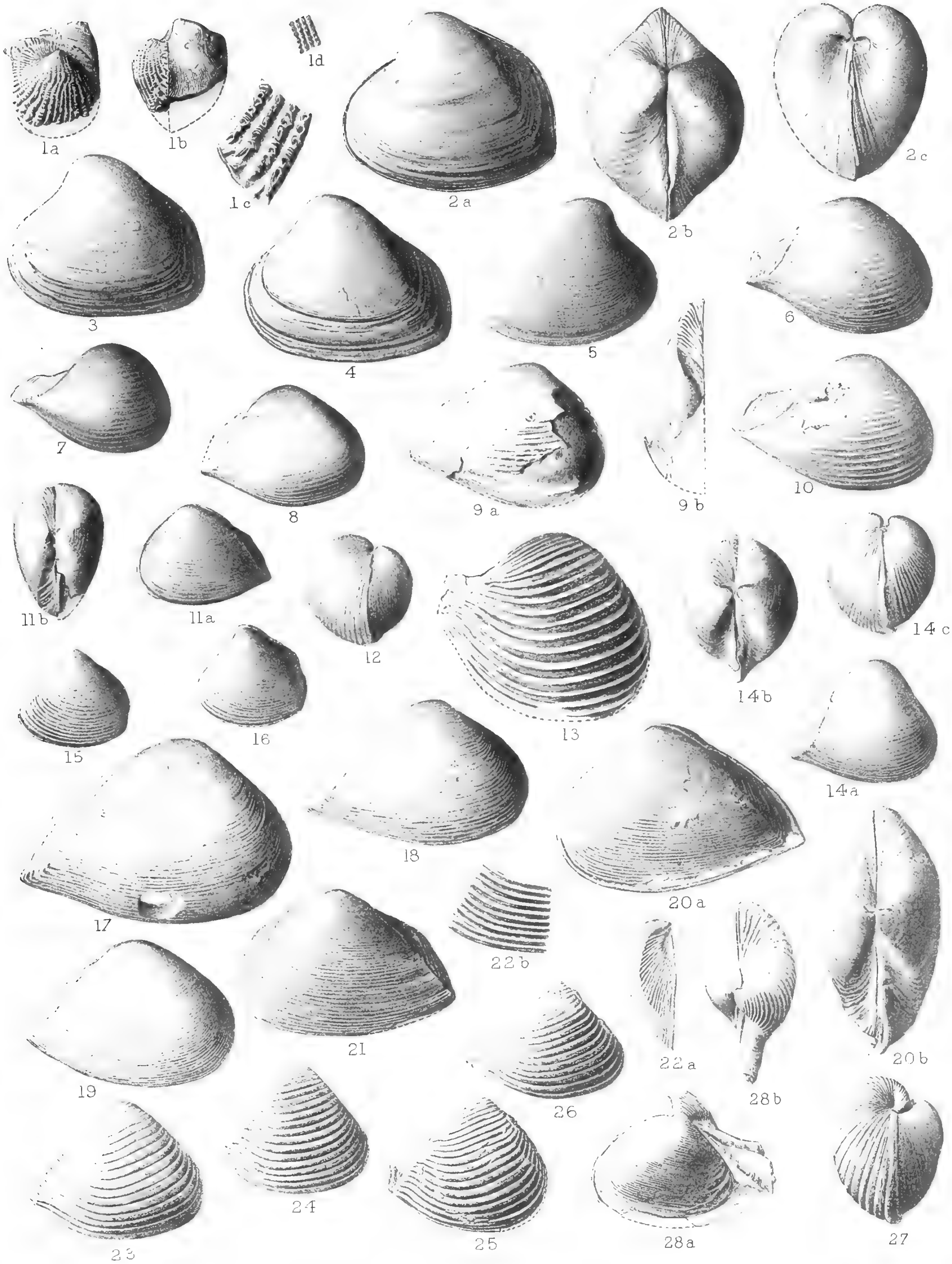
17—19. Right valves.
20, 21. Left valves. 20 *b*, dorsal view of 20 *a*.
22 *a*, posterior view of left valve × 5; *b*, ornamentation near the middle of the ventral margin × 10.

23—28. *C. elegans*, Sow. Upper Greensand, Blackdown. Sedgwick Museum. × 5. (P. 216.)

23—26. Right valves.
27. Anterior view of both valves.
28 *a*, left valve and umbo of right valve; *b*, dorsal view of *a*.

PALÆONTOGRAPHICAL SOCIETY, 1908

Vol. II PLATE XXXIV



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THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

LONDON

MDCCCXCI—MDCCCCVIII.

MONOGRAPH OF THE BRITISH FOSSIL ECHINODERMATA FROM THE CRETACEOUS FORMATIONS.

Vol. II.—Asteroidea and Ophiuroidea.

Mr. Sladen is the author of pages 1—66, Plates I—XVI, while Mr. Spencer is the author of the remainder of the Volume. Mr. Spencer desires to express his indebtedness to Dr. F. A. Bather for much help and advice in his share of the work.

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67—90	XVII—XXVI	1905	November, 1905
91—132	XXVII—XXIX	1907	December, 1907
133—138 (including Index)	—	1908	December, 1908

The Plates are intended to be collected and bound at the end of the Volume.

A MONOGRAPH

ON THE

BRITISH FOSSIL

ECHINODERMATA

FROM

THE CRETACEOUS FORMATIONS.

VOLUME SECOND.

THE ASTEROIDEA AND OPHIUROIDEA.

BY

W. PERCY SLADEN, F.L.S., F.G.S.,

AND

W. K. SPENCER, B.A., F.G.S.

LONDON:

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1891—1908.

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Palæontographical Society, 1908.

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W. K. SPENCER, B.A., F.G.S.

PART FIFTH.

Pages 133—138; Title-page and Index.

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almost all Cretaceous Asteroids, and in quite young forms of the order "Cryptozonia," the margin of the disc and arms is bordered by specially prominent plates —the "Marginalia." The abactinal series are called "Supero-marginalia," and the actinal series the "Infero-marginalia."

Primary Inter-radialia.—See *Centrale.*

Radialia.—The abactinal series of plates along a major radius are called the radialia.

Radius.—A line drawn from the central point of the disc to an extremity of the arm is called the "*Major radius,*" R. A line drawn from the central point of the disc to a point half-way between two radii is called the "*Minor radius,*" r. This is sometimes called an "*Inter-radius.*"

Spine-pits.—Depressions in a plate for the articulation of spines (see p. 113).

Ventro-lateralia.—The plates on the actinal surface of the Asteroid excluding the infero-marginalia and the adambulacralia. In the inter-radial regions these plates are often rhomboidal. A typical view of an isolated plate of this description is given (Pl. XXIX, fig. 4).

ADDENDA ET CORRIGENDA.

Page 24, line 19, for *Schülze* read *C. F. Schulze.*

Page 26, *Locality, etc.*, for *Upper White Chalk near Norwich* read *Hard Chalk, West Norfolk, the precise locality unknown.*

Page 67, line 11, for *Goniaster compactus* read *Goniaster* (*Goniodiscus*) *compactus*, and omit all reference to Forbes, 1848.

Page 69, line 15, for *Stellaster comptoni* read *Goniaster* (*Stellaster*) *Comptoni.*

Page 71, line 4, for *Stellaster elegans* read *Goniaster* (*Stellaster*) *elegans.*

Page 89, line 8 from end, for *Bourguetiocrinus* read *Bourgueticrinus.*

Page 90, last line, for *Upper Greensand* read *Lower Chalk.*

Page 95, line 3, for *Sladen* read *Forbes.*

Page 95, line 13, for (*p. 89*) read (*p. 89, Pl. XXV, fig. 7*).

Page 101, line 9 from end, the first reference should read OPHIURA, *Lamarck*, 1801. *Systeme des Animaux sans Vertebrés*, p. 350. The date of the reference given is 1816.

Page 102, line 12, for *1841* read *1840.*

Page 103, line 10, add *cor-anguinum zone, Northfleet, Kent, and Blandford, Dorset.*

Page 103, line 11, add in synonym: Ophiura serrata? *Forbes*, 1843. *Proc. Geol. Soc., vol. iv, p.* 234.

Page 103, line 4 from end, for *parvisentum* read *parvisentis.*

Page 106, line 7, after *E5060* add *and E5061*; under *Locality* insert *Folkestone.*

Page 117, line 12 from end, for *M.* read *Metopaster.*

Page 117, line 7 from end, for *M.* read *Mitraster.*

Page 117, line 2 from end, for *M.* read *Metopaster.*

Page 118, line 3 from top, for *M.* read *Mitraster.*

Page 118, line 7 from top, for *M.* read *Metopaster.*

Page 118, line 9 from top, for *M.* read *Metopaster.*

Page 118, line 12 from top, for *M.* read *Mitraster.*

Page 119, line 3 from end, for *bipunctatus* read *bispinosus.*

Page 120, line 13 from end, for *bipunctatus* read *bispinosus.*

Page 130, table and line 7 from end, for *bipunctatus* read *bispinosus.*

Page 121, lines 2, 4, 6, for *S.* read *Stauranderaster.*

Pl. IV, figs. 2—4, for *Lower* read *Upper.*

Pl. V, fig. 1, for *Tomidaster sulcatus* read *Calliderma Smithiæ* (see p. 123).

Pl. VII, figs. 1 *a* and 2 *a*, for *? Nymphaster Coombii* read *Calliderma Smithiæ* (see p. 122).

Pl. X, fig. 4, for *Metopaster Parkinsoni* read *Metopaster uncatus* (see p. 124).

Pl. XIX, fig. 3, for *Nymphaster Coombii* read *Calliderma Smithiæ* (see p. 122).

Pl. XXI, fig. 2, for *Pentagonaster robustus* read *? a young form of Pycinaster angustatus* (see p. 95).

Pl. XXIV, fig. 1, for *Pentaceros abbreviatus* read *Hadranderaster abbreviatus* (see p. 125).

Pl. XXV, fig. 2, for *Upper Greensand* read *Lower Chalk.*[1]

Pl. XXV, fig. 6, for *Genus ? sp. ?* (p. 93) read *? Stauranderaster argus* (p. 99).

Pl. XXV, fig. 7, for *Pentaceros ? n. sp.* (p. 89) read *Pycinaster angustatus* (pp. 89, 95).

Pl. XXV, fig. 8, for *marginal* read *internal.*

Pl. XXVI, fig. 1, for *Pentaceros punctatus* read *Pycinaster senonensis* (see p. 95).

Pl. XXVI, fig. 4, for *Calliderma mosaicum* read *Pycinaster angustatus* (see p. 95).

Pl. XXVI, fig. 4, for *From the Lower Chalk* read *From the Upper Chalk.*

Pl. XXVII, fig. 3 *b*, for *abactinal* read *actinal* or *adoral.*

Pl. XXVII, fig. 3 *c*, for *side* read *right side.*

[1] Mr. H. Woods informs me that recently he has been able to match the matrix in which this fossil is embedded.

Pl. XXVII for *Ophiura parvisentum* read *Ophiura parvisentis*.

Pl. XXVII, fig. 4, before *natural size* insert *slightly less than*.

Pl. XXIX, fig. 12, for *Sladen sp.* read *Sladen*.

On all Plates (except XXVI) for *Calliderma mosaicum* read *C. Smithiæ* (see p. 122).

On all Plates for *Metopaster Bowerbankii*, *M. Mantelli*, *M. zonatus*, read *M. Parkinsoni* (see p. 124).

On all Plates for *Metopaster cingulatus* read *M. uncatus* (see p. 124).

On all Plates for *Pentaceros bulbiferus*, *P. Boysii*, *P. coronatus*, *P. bipunctatus*, *P. squamatus*, *P. pistilliferus*, *P. ocellatus*, *P. argus*, read *corresponding species of Stauranderaster* (see p. 125).

On all Plates for *Pentagonaster megaloplax*, read *P. quinqueloba* (see p. 108).

INDEX.

ADLARD AND SON, IMPR., LONDON AND DORKING.

Palæontographical Society, 1908.

A MONOGRAPH

OF THE

BRITISH CAMBRIAN TRILOBITES.

BY

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one quarter the width of the head, bounded by well-defined axial furrows, and in front by a strong furrow separating it from the frontal limb; neck-furrow distinct, but no definite glabellar furrows. Cheeks wide, moderately convex, sometimes with a prominent ridge extending from the anterior corners of the glabella to the genal angles; united in front of the glabella by a prominent frontal limb; occipital furrows strong; a small lobe separated off from the cheek in the angle between the axial and the occipital furrows. Eyes crescentic, placed near to the occipital furrow, and about halfway between the glabella and the external margin. Facial suture marginal or infra-marginal in front; running nearly straight backwards to the eye, then outwards to the marginal rim, and finally backwards and a little inwards to the posterior margin. Margin forming a narrow raised rim, uniform in width, striated on the doublure. Genal angles produced into long slender spines, which curve at first a little outwards and then backwards, extending far beyond the tail.

Thorax of seven, or sometimes fewer, segments, narrowing slightly towards the posterior extremity. Axis forming nearly one third of the total width in the first three segments, narrowing posteriorly. Pleuræ straight, horizontal, grooved, the first three terminating in blunt points, the rest truncate and apparently bent downwards at the tips.

Tail wide but very short, forming a flat triangle. Axis narrow, conical, reaching nearly to the posterior margin, showing traces of four rings. Lateral lobes flat, with a very faint furrow near the anterior margin. Margin bent downwards.

The largest specimens attain a length (exclusive of the genal spines) of nearly 2 cm.

This species is closely allied to *O. elatifrons*, and the differences are probably even less than they appear at first sight, and are due in part to the less perfect preservation of the specimens. In the specimen figured the glabella is more quadrate than in the Shineton form and is not produced posteriorly into a spine, but it is somewhat flattened by pressure, and other specimens from the same locality suggest, though they do not prove, that the glabella was not very different in shape from that of *O. elatifrons*, and was perhaps produced posteriorly in a similar fashion. There are, however, other differences which appear to be real. In *O. elatifrons* the space in front of the glabella, between it and the raised marginal rim, is concave; in *O. prænuntius* it is convex, and is separated from the glabella by a distinct furrow. The ridges which run across the cheek from the anterior corners of the glabella to the genal angles are absent in *O. elatifrons*, but they are not always very distinct even in the present species.[1] The genal spines in

[1] These ridges are similar to those described and figured by Salter in *Trinucleus gibbsi* (Mem. Geol. Surv., vol. iii, p. 319, pl. xii, fig. 10), and, as appears to be the case in that species, are probably only the result of lateral pressure acting upon a rather abrupt bend.

O. prænuntius are longer than in *O. elatifrons*, and, where they spring from the cheeks they are often more strongly bent outwards. In both species the number of thoracic segments may vary, even in forms which in other respects appear to be adult. In *O. prænuntius* none of the specimens have more than seven; in *O. elatifrons* the few specimens which afford any evidence on this point have either eight or nine.

The type specimens of Salter's *Ampyx prænuntius* are unfortunately unknown, and appear to have been lost; but Salter states that in this form the glabella is short and not produced to the margin, and there is a narrow convex rim around the head. In these characters it agrees with *Orometopus* and differs from the true *Ampyx*. The specimens were found at Pen-y-clogwyn, near Tremadoc; and in the Jermyn Street Museum there is a specimen from this locality which was labelled *Ampyx* but which belongs to the species here described. Further, Mr. Fearnsides tells me that the beds at Penmorfa, in which his specimens of *Orometopus prænuntius* were found, may be traced to Pen-y-clogwyn, where the same horizon is seen. There is, therefore, very strong presumptive evidence that the species here described is identical with Salter's *Ampyx prænuntius*.

Horizon and Localities.—Upper Tremadoc: Pen-y-clogwyn and Penmorfa, near Tremadoc; Ceunant-y-garreg-ddu and Amnodd Bwll, Arenig. The Amnodd Bwll specimens occur in material of the same character as the specimens of *Shumardia pusilla* var. *morvensis* from the same locality.

Family OLENIDÆ.

Genus **OLENUS**, Dalman emend. Angelin.

The name *Olenus* was substituted by Dalman for the name *Paradoxides* previously proposed by Brongniart, and the species which he enumerates are nearly the same as those given by the latter author. The only exceptions are that Dalman places in this genus the *Entomostracites bucephalus* of Wahlenberg and removes the *Entomostracites laciniatus* of the same writer. Brongniart's genotype was *Paradoxides tessini*, and when it became necessary to divide the genus, the name *Paradoxides* was limited to those forms in which the glabella is swollen in front, while Dalman's term *Olenus* was by common consent employed for those in which the glabella is rectangular or parabolic in outline. Subsequent discovery showed that even with this limitation the genus *Olenus* is too large and varied to admit of satisfactory definition, and Angelin accordingly restricted it to forms of the type of *Olenus gibbosus* and *Olenus truncatus*. The name, however, is still very often employed in a wider sense, and the following table by E. Persson[1]

[1] Geol. Fören. Stockholm Förh., vol. xxvi (1904), p. 525.

will be found useful. It shows the distinguishing features of the more important genera which are commonly included under the name of *Olenus* sensu lato.

I. **Inermes**.—No cheek-spines . .		8. *Acerocare*.—Tail entire.
		7. *Peltura*.—Tail spined.
II. **Abruptæ**.—Cheek-spines abruptly projecting from the outer border of the cheek	(A) Pleuræ with long spines	6. *Sphærophthalmus*. — Glabella considerably higher than the strongly arched cheeks.
		5. *Ctenopyge*. — Fixed cheeks flat, inclined to the glabella.
	(B) Pleuræ with short spines	4. *Leptoplastus*.—Cheek - spine short, slightly bent.
		3. *Eurycare*.—Cheek-spine long, broad, strongly bent.
III. **Continuæ**.—Cheek-spines in direct continuation of the outer margin of the cheek		2. *Parabolina*.—Strong spines to tail.
		1. *Olenus*.—Tail entire, or with rudimentary spines.

In the section **Abruptæ** the cheek-spines originate well in front of the posterior margin and spring abruptly from the outer border of the head, making a distinct angle with the exterior margin. In the **Continuæ** the cheek-spines, as in most Trilobites, arise at the genal angles, and the outer edge of the spine is the direct continuation of the outer border of the head.

In Persson's classification no place is found for Brögger's sub-genus *Parabolinella*. It is, however, one of the **Continuæ**, and as the tail is without spines it falls into the same division as *Olenus* proper. In several other respects it is more closely connected with *Olenus* than with *Parabolina*.

Limiting the genus *Olenus* to the species similar to *Olenus gibbosus* it may be defined as follows:

General form depressed, ovate. Head nearly semi-circular, with the genal angles produced into spines, which are in direct continuation of the outer margin of the cheeks. Glabella nearly rectangular, but narrowing slightly towards the front, with two or three pairs of oblique glabellar furrows. Facial suture running from the anterior margin backwards to the eye, and thence backwards and outwards to the posterior margin, cutting the latter some distance within the genal angle. Eyes placed slightly in front of the middle of the cheek, and some distance from the glabella, connected with the glabella by a distinct ocular ridge. Thorax of 13—15 segments; the anterior pleuræ facetted, slightly bent downwards beyond the fulcrum, the posterior pleuræ nearly horizontal, without fulcrum or facet; all the pleuræ spined and grooved. Tail small, semi-circular or triangular, sometimes entire, sometimes with a small spine at the anterior angles.

1. **Olenus truncatus** (Brünnich). Plate V, figs. 1—7.

1781. *Trilobus truncatus*, Brünnich, Kong. Dansk. Vidensk. Selsk. Skrift., Nye Samling, Förste Deel, p. 391.

1827. *Trilobites gibbosus* var., Boeck (pars), Mag. for Naturv., 1827, p. 24, fig. 8.

1838. *Trilobites gibbosus* var., Boeck (pars), Keilhau's Gæa Norv., p. 143.

1843. ? *Olenus gibbosus*, Burmeister, Organ. d. Trilob., p. 81, pl. iii, fig. 9.

1854. *Olenus truncatus*, Angelin, Pal. Scand., p. 43, pl. xxv, fig. 1.

1857. *Olenus gibbosus* var., Kjerulf, Geol. d. südl. Norw., p. 284.

1865. *Olenus gibbosus* var., Kjerulf, Veiviser ved geol. excursioner i Christiania omegn, p. 2.

1882. ? *Olenus truncatus*, Brögger, Die Silur. Etagen 2 und 3, p. 98, pl. xii, figs. 5, 5 *a*—*c*.

Our British specimens of this species being very much compressed and distorted, the following description is based on specimens from Andrarum in Scania.

Head about two and a half or three times as broad as it is long, straight in front. Glabella narrow, less than the width of the cheeks, short, separated from the front margin by a space about equal to half its own length, nearly parallel-sided, truncate in front, with three pairs of glabellar furrows and a well-marked occipital furrow. Cheeks wide. Eyes fairly large, crescentic, placed nearly in the middle of the cheeks, distant from the glabella considerably more than half the width of the latter, connected with the anterior corner of the glabella by a straight ocular ridge which runs at right angles to the axis. Facial suture running slightly outwards from the anterior margin to the eye, and behind the eye curving rather strongly outwards and meeting the posterior margin some distance within the genal angle. Free cheeks bent somewhat downwards, with faint vascular markings which radiate from the eye; the posterior border of the free cheek not quite in line with that of the fixed cheek but turning slightly forwards. Margin narrow. Genal spines short, directed outwards.

Thorax of thirteen segments, narrowing backwards from about the seventh or eighth segment. Axis a little wider than the pleuræ. Pleuræ straight, in the first five or six segments bent slightly downwards near the tips and with articulating facets, in the later segments nearly horizontal and not facetted; in the anterior segments bluntly pointed, in the later segments produced into short spines, the spine on the tenth segment being apparently the longest; all the pleuræ grooved, the groove being rather broad and, except near the extremities, lying in the middle of the pleura.

Tail small, triangular. Axis broad, consisting of five segments, reaching nearly, if not quite, to the posterior margin; bluntly conical. Lateral lobes narrower than the axis, with (on each side) three distinct broad grooves, and a fourth indistinct, all the grooves nearly at right angles to the axis, the ribs between the grooves marked by a fine intermediate line. Margin narrow, without spines.

Dimensions.—Full-grown specimens commonly attain a length of 20—25 mm.

The British specimens of *Olenus truncatus* with which I am acquainted are invariably very badly preserved and have often been mistaken for *Olenus cataractes*. Belt, however, recognised the presence of the species in the Dolgelly district. From *O. cataractes* it is easily distinguished by the shortness of the glabella, which is only about half as long as the head, while in *O. cataractes* it extends nearly to the anterior margin. The breadth of the cheeks, the distance of the eye from the glabella, and the triangular tail with five segments to the axis also serve to distinguish *O. truncatus* from *O. cataractes*.

In the very imperfect state in which the specimens are usually found in Britain it is not always easy to separate *O. truncatus* from *O. gibbosus*. The head of *Olenus truncatus* is broader in proportion to its length and is straight or even emarginate in front, while in *O. gibbosus* the outline is nearly a segment of a circle. The genal spines of *O. truncatus* are directed somewhat outwards, while in *O. gibbosus* they run directly backwards. The axis of the thorax is narrower in *O. gibbosus*, and there are fifteen instead of thirteen thoracic segments. In *Olenus truncatus* the axis of the tail is broad and consists of five segments, and the lateral lobes are narrow; in *O. gibbosus* the axis is narrow and consists of at least seven segments, while the lateral lobes are comparatively broad. The margin of the tail is entire in *Olenus truncatus*, while in *O. gibbosus* it bears a small spine on each side, but it is not often that the spine is sufficiently well preserved to be distinct.

Olenus micrurus is easily distinguished by its long glabella and small quadrate tail; *O. longispinus* by its long backwardly-directed genal spines and its broad and short tail, which has a circular rather than triangular outline.

Synonymy.—The earlier writers do not distinguish between the *Trilobus truncatus* of Brünnich and the *Entomostracites gibbosus* of Wahlenberg, and Brünnich's own account would apply equally well to either species. He gives the number of segments as twenty, but probably he included the rings of the tail, and it may be remarked that he reckons twenty-four segments in his *Trilobus* [*Calymene*] *tuberculatus*. Wahlenberg identifies Brünnich's species with his own *Entomostracites paradoxissimus*, which is a *Paradoxides*. Dalman and Burmeister give *Trilobus truncatus* and *Entomostracites gibbosus* as synonyms.

Angelin appears to have been the first to recognise the differences, and his definition of the two species has been accepted by most subsequent authors.

The form *Trilobites gibbosus* var. of Boeck and *Olenus gibbosus* var. of Kjerulf is not sufficiently described by those authors to be identified, and it is on the authority of Brögger that I have included it in the synonymy. The species figured by Brögger himself and referred by him with some doubt to *Olenus truncatus* shows six distinct segments in the axis of the tail.

Horizon and Localities.—Lower Lingula Flags: Dolgelly; Cae Gwernog, Mawddach Valley.

2. **Olenus gibbosus** (Wahlenberg). Plate V, figs. 8—10.

1821. *Entomostracites gibbosus*, Wahlenberg, Petrif. Tell. Suec., p. 39, pl. i, fig. 4.
1822. *Paradoxides gibbosus*, Brongniart, Crust. Foss., p. 35, pl. iii, fig. 6.
1827. *Olenus gibbosus*, Dalman, Om Palæad., K. Vet. Akad. Handl. (1826), p. 256.
1837. *Olenus gibbosus*, Hisinger, Leth. Suec., p. 19, pl. iv, fig. 3.
1854. *Olenus gibbosus*, Angelin, Pal. Scand., p. 44, pl. xxv, fig. 5.
1867. *Olenus gibbosus*, Belt, Geol. Mag., vol. iv, p. 295, pl. xii, fig. 5 *a*, *b*.

Head rather more than twice as broad as it is long, the outline forming a segment of a circle. Glabella prominent, raised above the level of the cheeks, narrower than the cheeks, short, separated from the front margin by a space about equal to half its own length, narrowing slightly towards the front, truncate, with three pairs of oblique glabellar furrows, of which the first pair is very indistinct, occipital furrow well defined. Eyes moderate, crescentic, placed nearly in the middle of the cheeks, distant from the glabella more than half the width of the latter, connected with the anterior angles of the glabella by straight ocular ridges which run nearly at right angles to the axis. Facial suture running backwards and slightly outwards from the anterior margin to the eye and thence more strongly outwards to the posterior margin, which it cuts some distance within the genal angle. The cheeks and frontal limb slope steeply downwards in front of the glabella, less steeply towards the sides; fixed cheeks rather wide; free cheeks with faint vascular markings which radiate from the eyes. Margin narrow, upturned in front. Genal angles produced into spines which are directed backwards.

Thorax of fifteen segments, narrowing backwards from the sixth or seventh segment. Axis narrower than the pleuræ. Pleuræ straight and nearly horizontal, the anterior segments facetted; anterior segments pointed, the later segments produced into spines; all the pleuræ grooved, the grooves being slightly oblique.

Tail triangular. Axis narrow, rather less than the width of the lateral lobes in front, almost cylindrical, with either six or seven distinct rings besides the terminal portion, reaching to the posterior margin. Lateral lobes flat, with about four shallow and rather indistinct furrows, the ribs between being interlined. No definite marginal rim; a minute lateral spine on each side opposite the third axial ring.

Dimensions.—The British specimens are very variable in size, but sometimes attain a length of 35 mm. or more.

The presence of this species in the Lingula Flags of the Dolgelly district was recognised by T. Belt. Many of the specimens are complete, but the state of

preservation is poor. It is, however, readily distinguished from all the other British species of the genus except *O. truncatus* and *O. longispinus* by the shortness of its glabella. From *O. truncatus* it is distinguished by the rounded outline of the head, the backwardly-directed genal spines, the narrow axis of the tail and thorax, and the larger number of rings on the axis of the tail. The thorax consists of fifteen segments instead of thirteen as in that species, and the tail bears minute lateral spines. Owing to the state of preservation, however, it is seldom possible to make use of the last two characters.

From *O. longispinus* it is distinguished by the course of the facial suture in front of the eye, the number of segments in the thorax and the tail, and the outline of the tail, which, in *O. longispinus*, is circular rather than triangular.

Horizon and Locality.—Lower Lingula Flags: Tyn-y-groes, Dolgelly.

3. **Olenus micrurus,** Salter. Plate V, figs. 11, 12.

1849. *Olenus micrurus,* Salter, Mem. Geol. Surv., Brit. Org. Remains, dec. ii, pt. ix, p. 1, pl. ix, figs. 1, 2 (fig. 3 doubtful).

1866. *Olenus micrurus,* Salter, Geology of North Wales, Mem. Geol. Surv., vol. iii, p. 300, pl. ii, fig. 5 (fig. 6 doubtful).

General form depressed, narrowing somewhat rapidly towards the tail.

Head semi-circular. Glabella forming about one third the width of the head, reaching forwards nearly to the anterior margin; almost oblong in shape, but narrowing very slightly and somewhat rounded in front, with a well-marked neck-furrow and two (or possibly three) pairs of oblique glabellar furrows. Eyes moderate, set a little in front of the middle of the cheeks and distant from the glabella less than half the width of the latter, united with the anterior extremity of the glabella by an oblique ocular ridge (which is very imperfectly shown in the type specimen). Facial suture running from the anterior margin backwards to the eye, and thence backwards and outwards to the posterior margin, which it cuts some distance within the genal angle. Margin narrow, even in width. Genal spines short, directed somewhat outwards as well as backwards.

Thorax of fourteen segments, increasing slightly in width to the sixth or seventh segment, and thence decreasing rapidly, the last two segments being very narrow. Axis forming nearly one third of the total width in the anterior segments, more than one third in the posterior segments. Pleuræ straight and horizontal, obliquely grooved, the anterior pleuræ slightly facetted; all, except perhaps the first two, produced into backwardly-directed spines, which appear to attain their greatest length about the seventh segment.

Tail very small, subquadrate, slightly emarginate behind the axis. Axis cylindrical, wider than the lateral lobes, reaching to the posterior margin, showing only one ring marked off from the rest. Lateral lobes flat, with a faint furrow

near the anterior border. Margin forming a raised rim, produced into a very short spine on each side at the anterior angle.

Dimensions.—The length of the type-specimen shown in Plate V, fig. 12 must have been about 35 mm.

The length of the glabella, which reaches nearly to the anterior margin, distinguishes *Olenus micrurus* from all the other British species of the genus excepting *O. cataractes* and *O. mundus*, and from these forms it is separated chiefly by the characters of the thorax and the tail. In *O. cataractes* and *O. mundus* the general shape is ovate, while in *O. micrurus* the body tapers rapidly from the sixth or seventh thoracic segment, and the pleuræ of the last two segments are very short. The tail of *O. micrurus* is quite characteristic, with only one ring differentiated upon the axis, and with the lateral lobes narrow and showing only one faint furrow near to the anterior border.

The presence of the small spine at the anterior angles of the tail is not noted by Salter, but it is distinctly visible in the specimen figured on Plate V, fig. 12, which was one of his types. It is, however, by no means conspicuous, and can only be seen when the specimen is lighted in a particular direction.

Olenus micrurus is commonly quoted as a characteristic species of the Lingula Flags, but so far as I am aware the only specimens in our museums which can be referred with certainty to this species, are the two from near Trawsfynydd which are shown in Plate V and upon which Salter's figure appears to have been based. The specimens from the Cwm-y-Swm Mine and from Marchllyn Mawr, to which he refers, are much too imperfect for specific determination.

Horizon and Locality.—Lower Lingula Flags: Trawsfynydd.

4. **Olenus cataractes**, Salter. Plate V, figs. 13—17; Plate VI, fig. 1.

1864. *Olenus cataractes*, Salter, Mem. Geol. Surv., Brit. Org. Rem., dec. xi, pt. viii, p. 1, pl. viii, figs. 14, 14 *a*, *b*.

1866. *Olenus cataractes*, Salter, Geology of North Wales, Mem. Geol. Surv., vol. iii, p. 300, pl. v, figs. 23, 23 *a*, *b*.

1878. *Olenus caractaci*, Salter MS., Cat. Camb. and Sil. Foss. Mus. Pract. Geol., p. 10.

Head semi-circular, marginate, produced into spines at the genal angles. Glabella about one third the width of the head, reaching nearly to the anterior margin, nearly parallel-sided but narrowing very slightly forwards, rounded in front, with a well-defined neck-furrow and three pairs of oblique glabellar furrows, of which the first is very faint. Cheeks wide, free cheeks sometimes with faint vascular markings radiating from the eye. Eyes small, crescentic, placed a little in front of the middle of the cheeks, and distant from the glabella about half the

width of the latter, united with the anterior end of the glabella by a very faint ocular ridge. Facial suture running from the anterior margin backwards to the eye, and thence backwards and outwards to the posterior margin, which it cuts some distance within the genal angle. Margin narrow, even in width; genal angles produced into spines which are directed backwards and are about as long as the head.

Thorax of fourteen or fifteen segments, decreasing in width from the sixth or seventh segment backwards. Axis about equal in width to the pleuræ. Pleuræ nearly straight and horizontal, obliquely grooved; the fulcrum of the first segment placed about half way between the axis and the extremity of the pleura, in the following segments successively further out until in the seventh or eighth segment it has disappeared; outside the fulcrum the pleuræ are slightly bent downwards and facetted, and end in short points; beyond the seventh segment there is no facet and the extremities are produced into spines directed backwards, the spine of the tenth segment being the longest.

Tail small, sub-triangular. Axis forming about one third of the whole width, conical, terminating bluntly a little in front of the margin, composed of four segments (including the terminal portion). Lateral lobes flat, with three broad, shallow, outwardly-directed grooves, of which only the first is well defined; the ridge between the first two grooves marked by a narrow impressed line. Margin narrow, even, bearing on each side near the anterior angles a short, sharp, backwardly-directed spine.

Dimensions.—Very variable, length from 10—40 mm.

From *Olenus truncatus*, *O. gibbosus*, and *O. longispinus* this form is readily distinguished by the length of the glabella, which reaches forwards nearly to the anterior margin, and this character is easily recognised even in very imperfect specimens. *Olenus micrurus* presents a closer resemblance, and is distinguished chiefly by the rapid narrowing of the hinder part of the thorax, the smallness of the tail, and the presence of only one distinctly differentiated ring upon the pygidial axis.

It often happens that in distorted specimens *Olenus cataractes* presents a striking general resemblance to *Parabolina spinulosa*, and this is especially the case when the specimen is laterally compressed. The thoracic segments then appear to terminate in long spines, and even the tail may seem to bear several spines, while the characters of the head are not strikingly different. It will be observed, however, that the eye is placed considerably further back than in *Parabolina spinulosa*, and the thorax is not provided with a row of tubercles upon the axis. These characters will usually serve to distinguish between the two forms in all but the most fragmentary specimens.

But the form with which *O. cataractes* is most nearly allied is *O. mundus*,

which is found along with it at Trefgarn Bridge. So close, indeed, is the resemblance that the latter may ultimately prove to be only a young stage of *O. cataractes*. There are, however, certain differences which appear to be constant, and I have not yet discovered any intermediate forms. In *O. mundus* the ocular ridge is much more strongly marked, the pleural spines are shorter, the axis of the thorax bears a median tubercle upon each segment, and the axis of the tail has only two or possibly three rings differentiated upon it instead of four. Owing, however, to the small size of the specimens and the increasing vagueness of the segmentation towards the end of the axis, but little importance can be attached to the last character. *O. cataractes* is usually considerably larger than *O. mundus*, but occasional specimens approach the latter in size.

Salter's figure of *Olenus cataractes* is evidently a restoration, but he states that the specimen is from Treflys and is in the Museum of Practical Geology, and hence it would appear that the specimen upon which the restoration is chiefly based must be that which is shown in Plate V, fig. 13. He lays some stress upon the fact that the second and third pairs of glabellar furrows are continuous across, but this is a peculiarity which is often met with in other species of the genus and which appears to depend upon the mode of preservation—being due, in fact, merely to the crumpling of the test between two points of weakness. The really continuous glabellar furrows in such forms as *Sphærophthalmus alatus* present a very different appearance.

Owing to the imperfection of his material, Salter failed to observe the lateral spines of the tail, but they are very clearly shown in the beautiful specimens collected by Mr. Turnbull at Trefgarn Bridge, and they are distinctly visible in some of those from the Maentwrog Falls, although, owing to the compression and distortion of the specimens, they are liable to be overlooked.

Horizon and Localities.—Lower Lingula Flags: Caen-y-coed, Maentwrog Valley; Treflys, Criccieth; Portmadoc; Tal-y-sarnau; Trefgarn Bridge, Haverfordwest.

5. **Olenus mundus**, sp. nov. Plate VI, figs. 2—5.

General form depressed, ovate.

Head semi-circular, marginate, produced at the genal angles into short spines. Glabella not quite so wide as the cheeks, narrowing very slightly forwards, truncate in front, reaching nearly to the anterior margin, from which it is separated by a space rather wider than the margin itself; neck-furrow strong; three pairs of glabellar furrows, of which the second and third are strongly marked and very oblique, while the first is fainter and less oblique. Cheeks rather wide; free cheeks with faint vascular markings radiating from the eye.

Eyes of moderate size, set a little in front of the middle of the cheeks and distant from the glabella about half the width of the latter, united with the anterior end of the glabella by a strong ocular ridge which reaches the glabella just in front of the first glabellar furrow. Facial suture running from the anterior margin backwards and slightly outwards to the eye, and thence more decidedly outwards to the posterior margin, which it cuts nearly opposite to the end of the first thoracic pleura. Margin narrow, even in width; genal spines slender, short and sometimes bent slightly outwards.

Thorax of fourteen segments, considerably narrower than the head, the decrease in width regular and gradual. Axis rather wider than the pleuræ, bearing a row of median tubercles (which are rather indistinct). Pleuræ straight, the fulcrum of the first segment placed about half way out, in the later segments distant from the axis about two thirds the length of the pleuræ; pleuræ bent slightly downwards beyond the fulcrum, especially in the anterior segments, which are facetted. The points of the first segments very short and directed outwards, those of the later segments progressively longer and more and more backward in direction, but all are short.

Tail small, short, rounded or subtriangular. Axis conical, blunt, forming about one third the width, reaching to the posterior margin, consisting of three or four segments. Lateral lobes very slightly arched, marked by two fairly strong furrows with a fine intermediate line. Margin sometimes slightly expanded at the anterior angles, as if it bore a small spine.

Dimensions.—Length 6 or 7 mm.

The only species with which this form is likely to be confounded is *Olenus cataractes*, and from this it is distinguished by its small size, the prominence of the ocular ridges, the shortness of the pleural spines and the presence of tubercles on the axis of the thorax. All these, except the last, are characters which might reasonably be expected to disappear with age, and it is quite possible, therefore, that *O. mundus* is the young of *O. cataractes*. It is the absence of intermediate forms and the presence of the axial tubercles in the smaller form which prevent me from accepting this view without further evidence.

Olenus mundus was found by Mr. V. M. Turnbull at Trefgarn Bridge, Haverfordwest, along with *Olenus cataractes* and several minute and immature forms, which may be the young of either species. The material in which they lie is scarcely fine enough to preserve the details of these larval forms, and the margins of the heads and tails and the extremities of the pleuræ are usually lost or buried in the matrix. The most nearly perfect of the specimens is shown in Plate VI, fig. 4, and in this the glabella extends forwards to the anterior margin and is completely divided by transverse furrows into five segments, of which the last appears to represent the occipital ring. The ocular ridge springs from the

first segment and runs close to the exterior margin, reaching nearly half way to the genal angle. The thorax seems to consist of six segments and the tail of three, but the division between the two regions is indistinct. The other specimen figured is not so nearly perfect, but shows the margin of the head more clearly.

The presence of these young forms is, perhaps, an additional argument in favour of the view that *Olenus mundus* is merely a stage in the development of *Olenus cataractes*.

Horizon and Locality.—Lower Lingula Flags: Trefgarn Bridge, Haverfordwest.

6. **Olenus longispinus** (Belt). Plate VI, figs. 6, 7.

1868. *Conocoryphe ? longispina*, Belt, Geol. Mag., vol. v, p. 9, pl. ii, figs. 12—14.

Head nearly semi-circular, with the genal angles produced into long, slender, backwardly-directed spines. Glabella very short, nearly as broad as long, about two thirds the length of the head, and rather less than one third the width, nearly parallel-sided, truncate in front, with two pairs of oblique glabellar furrows. Eyes placed in the middle of the cheeks, distant from the glabella rather more than half the width of the latter, united with the anterior angles of the glabella by strong curved ocular ridges which run nearly at right angles to the axis. Facial suture running inwards and backwards from the anterior margin to the eye, and thence outwards and backwards to the posterior margin, which it cuts nearly opposite to the end of the first thoracic pleura. Cheeks moderately convex. Margin narrow; genal angles produced into long, slender, backwardly-directed spines, which reach nearly as far as the end of the tail.

Thorax of fourteen segments, widening slightly to the sixth segment, and thence narrowing rather rapidly backwards. Axis about equal in width to the pleuræ in the anterior segments, narrower in proportion in the posterior segments, each axial ring with its lateral extremities tuberculate and also bearing a small median tubercle, which, however, is not always very distinct. Pleuræ straight, obliquely grooved, the anterior pleuræ distinctly bent down at the fulcrum and produced into short outwardly-directed points; the extremities of the later segments unknown.

Tail broad and short, rounded in outline. Axis narrower than the lateral lobes, reaching to the posterior margin, consisting of three or four rings. Lateral lobes flat, with three furrows. Margin entire.

Dimensions.—Length about 18 mm.

No other British species possesses the very long genal spines characteristic of this species. *Olenus truncatus* and *O. gibbosus*, both of which have short glabellas,

are the species which approach it most nearly in the characters of the head, but in *O. longispinus* the glabella is proportionally even shorter and considerably wider than in those forms, the sides are more nearly parallel, and it is more sharply truncate in front; the eyes are placed further back and nearer to the glabella, and the anterior branch of the facial suture runs inwards to the eye. In all the other British species the glabella reaches nearly to the anterior margin.

The thorax differs from that of the other British species excepting *O. mundus* in bearing a median tubercle upon each axial ring.

In the shortness and breadth of the tail the species is unlike any of the true Oleni.

As has already been observed by Mr. F. R. C. Reed,[1] *Olenus longispinus* presents several of the features characteristic of *Parabolinella*, and very possibly it should be referred to that genus. It is in the characters of the tail and the inward course of the anterior branch of the facial suture that the chief resemblance lies, but it differs from the typical species of *Parabolinella* in the extreme shortness of the glabella, the backward position of the eyes, and perhaps in the number of thoracic segments. It appears to be an intermediate form, but for the present I prefer to put it in *Olenus* rather than in *Parabolinella*.

Horizon and Locality.—Upper Lingula Flags: Dolgelly; Moel Gron; Penmorfa.

Genus **PARABOLINA**, Salter.

The genus *Parabolina* is closely allied to *Olenus*, but is distinguished by the following characters: The glabella is long, more or less truncate in front, and separated from the anterior margin by a very narrow frontal limb; the eyes are placed far forwards and very near to the anterior angles of the glabella; the thorax consists of twelve segments; the pleuræ are obliquely grooved and terminate in spines; the tail bears several spines upon each side.

The name was originally proposed by Salter in 1849[2] for a section of the genus *Olenus* (*sensu lato*), characterised by possessing twelve thoracic segments and a spinose tail. Angelin elevated this section to the rank of a distinct genus. It is undoubtedly a very clearly-defined group, and, as *Olenus*, in the wider sense, includes too great a variety of forms to admit of precise definition, I propose to follow Angelin's example.

[1] Geol. Mag. [4], vol. vii (1900), p. 254.

[2] Mem. Geol. Surv., Brit. Org. Rem., dec. ii, pt. ix, p. 2.

1. **Parabolina spinulosa** (Wahlenberg). Plate VI, figs. 8—11.

1821. *Entomostracites spinulosus*, Wahlenberg, Petrif. Tell. Suec., p. 38, pl. 1, fig. 3.
1822. *Paradoxides spinulosus*, Brongniart, Crust. Foss., p. 32, pl. iv, figs. 2, 3.
1827. *Olenus spinulosus*, Dalman, Om Palæad., p. 256, pl. vi, fig. 4.
1837. *Olenus spinulosus*, Hisinger, Leth. Suec., p. 19, pl. iv, fig. 2.
1838. *Trilobites gibbosus*, var. (pars), Boeck, Keilhau's Gæa norv., p. 143 (*teste* Brögger).
1843. *Paradoxides spinulosus*, Burmeister, Organ. d. Trilob., p. 80.
1854. *Parabolina spinulosa*, Angelin, Pal. Scand., p. 46, pl. xxv, fig. 9.
1857. *Olenus spinulosus*, Kjerulf, Geol. d. südl. Norw., p. 284 (*teste* Brögger).
1864. *Olenus* (*Parabolina*) *spinulosus*, Salter, Mem. Geol. Surv., Brit. Org. Rem., dec. xi, pt. viii, pl. viii, fig. 16.
1864. *Olenus* (*Parabolina*) *serratus*, Salter, ibid., p. 4, pl. viii, fig. 5.
1865. *Parabolina spinulosa*, Kjerulf, Veiviser ved geol. excursioner i Christiania omegn, p. 2.
1866. *Olenus* (*Parabolina*) *serratus*, Salter, Geol. of North Wales, Mem. Geol. Surv., vol. iii, p. 301, pl. v, figs. 6, 7.
1873. *Olenus* (*Parabolina*) *spinulosus*, Salter, Cat. Camb. and Sil. Foss. Mus. Cambridge, p. 11.
1882. *Parabolina spinulosa*, Brögger, Die Silur. Etagen 2 und 3, p. 100, pl. i, figs. 12 *a—e*.
1904. *Parabolina spinulosa*, Persson, Geol. Fören. Stockholm Förh., vol. xxvi, pl. ix, fig. 24.

Head forming approximately a segment of a circle but with the anterior margin nearly straight. Glabella rather less than one third the width of the head, almost rectangular but narrowing slightly towards the front and with the anterior angles rounded, reaching forwards nearly to the margin. Three pairs of oblique glabellar furrows, of which the first is shorter, less oblique and less strongly marked than the others; occipital furrow well defined especially at the sides, the occipital ring divided by two oblique furrows into a central portion which bears a median tubercle, and two anterior lateral portions. Eyes of moderate size, placed far forwards and very close to the anterior angles of the glabella, with which they are connected by strongly marked ocular ridges. Facial suture running directly backwards from the anterior margin to the eye, and thence outwards and backwards to the posterior margin, which it cuts nearly opposite to the extremity of the first thoracic pleura and some distance within the genal angle. Frontal limb very narrow; fixed cheeks very narrow in front of the eye, widening rapidly backwards, with a strong neck-furrow; free cheeks ornamented with branching and anastomosing ridges, which radiate from the eye; the posterior margin not in line with that of the fixed cheeks but turning slightly forwards. Head surrounded by a narrow marginal rim and furrow; genal angles produced into long, slender, backwardly-directed spines.

Thorax of twelve segments. Axis forming about one third of the whole width, each segment provided with a median tubercle. Pleuræ slightly bent downwards towards their outer extremities, produced into spines, which in the first few segments are rather short, but from the fifth or sixth segment onward are of considerable length; the spines of the first segment directed somewhat outwards,

those of the later segments progressively more and more directly backwards; all the pleuræ deeply grooved by oblique furrows which are continued into the spines.

Tail somewhat triangular, without any raised margin. Axis broad, conical, reaching to the posterior margin, formed of four segments (including the terminal portion), of which all but the last bear a median tubercle. Lateral lobes flat, composed, apparently, of three pleuræ similar to the posterior thoracic pleuræ, and each produced into a long backwardly-directed spine, the first pleura nearly at right angles to the axis, the others oblique. Besides the three spines on each side there is a pair of spines immediately behind the axis.

Dimensions.—Very variable; length from 8 to 30 mm., commonly about 25 mm.

The form with which *Parabolina spinulosa* is most likely to be confounded is *Olenus cataractes.* In perfect specimens the differences are sufficiently obvious; but, as has already been remarked in the account of *O. cataractes*, compressed specimens of that species often appear to bear long thoracic and pygidial spines. They may, however, be distinguished by the more backward position of the eyes and the absence of axial tubercles; and a close examination will usually show that the appearance of long spines is due to wrinklings on the surface of the slate in which the specimen lies.

Some of the British specimens of *Parabolina* are very small, and in some the spines of the tail and thorax seem to be very short, so that at first sight they appear to differ from *P. spinulosa.* I have, however, been unable to recognise any of the other species described by Moberg[1]; and the shortness of the spines seems to be due in some cases to the youth of the individual and in others to the fact that the extremities are imperfectly preserved. The specimen from Mr. G. J. Williams's collection shown in Plate VI, fig. 11, is one of the most distinct of these forms; but other specimens, which Mr. Williams has kindly lent me, and which came from the same locality, seem to indicate that there are stages intermediate between this and the normal *Parabolina spinulosa.* For the present, therefore, I look upon these small and short-spined forms as stages in the development of that species.

Horizon and Localities.—Upper Lingula Flags: Rhiwfelyn, Craig-y-Dinas, Mawddach Valley; Nant-y-derbyniad; Nant Cistfaen, Llyn Tryweryn; Bryn Cyfergyd, Cwm Cynfal; Carreg Wen, Borth; Penmorfa; Penmaenpool; Gwern-y-barcud, Dolgelly.

Genus **PARABOLINELLA,** Brögger.

The genus *Parabolinella* resembles *Parabolina* in some respects, but possesses an entire instead of a spinose tail. There are also other important differences, and the genus appears to be connected (through *Olenus longispinus*) with *Olenus* proper rather than with *Parabolina.*

[1] Geol. Fören. Stockholm Förh., vol. xx, pp. 259—277.

The glabella is rectangular, sometimes narrowing slightly towards the front, shorter than in *Parabolina*, with two or three pairs of glabellar furrows, of which the last two pairs are very oblique; the frontal limb between the glabella and the anterior margin is fairly wide. The eyes are placed about half way between the anterior and posterior margins and very close to the glabella, with the anterior angles of which they are connected by oblique ocular ridges. The facial suture runs inwards and backwards from the anterior margin to the eye and thence outwards and backwards to the posterior margin. The number of thoracic segments varies, but in the adult (in all the species in which the number is known) it is never less than fourteen. The tail is broad, rounded in outline, marginate, and without spines.

1. **Parabolinella williamsoni** (Belt). Plate VI, fig. 12.

1868. *Conocoryphe ? williamsonii*, Belt, Geol. Mag., vol. v, p. 9, pl. ii, figs. 7—11.
1873. *Olenus plantii*, Salter, Cat. Camb. Sil. Foss. Mus. Cambridge, p. 11.
1900. *Olenus* (*Parabolinella*) *planti*, F. R. C. Reed, Geol. Mag. [4], vol. vii, p. 303, pl. xii, fig. 1.

Head semi-circular. Glabella nearly rectangular, narrowing slightly towards the front and with the anterior angles somewhat rounded, separated from the marginal rim by a broad frontal limb; two pairs of glabellar furrows, both very oblique and both obsolete near the axial furrows, the last pair meeting in the middle of the glabella, the first pair nearly meeting; neck-segment defined by a furrow, which becomes weak towards the middle and obsolete near the axial furrows, obscurely divided into three portions by oblique furrows, which pass from the posterior lateral angles of the segment nearly to the middle of the occipital furrow; the central portion thus defined bears a very indistinct median tubercle. Eyes placed about half way between the anterior and posterior margins, very near to the glabella, with the angles of which they are connected by oblique ocular ridges. Facial suture running from the anterior margin backwards and inwards to the eye and thence backwards and outwards to the posterior margin, which it cuts at a distance from the axial furrow less than the width of the glabella. Margin formed by a narrow raised rim.

Thorax probably of fifteen segments. Axis as wide as the pleuræ in the anterior part of the thorax, but in the posterior part not much more than half the width of the pleuræ, some of the rings showing very obscure indications of median tubercles. Pleuræ straight, obliquely grooved, slightly bent down at the fulcrum, which in the anterior pleuræ is placed very near the axis, in the posterior pleuræ far out; the anterior pleuræ distinctly facetted and terminating in points directed

PLATE V.

FIGS. PAGE.

Olenus truncatus (Brünnich). 52

1–3. Swedish specimens. 1, nearly complete; 2, head; 3, free cheek. Olenus schists, Andrarum, Scania. Collected by Dr. J. E. Marr. Sedgwick Museum.

4–6. Some of Belt's specimens. Upper Maentwrog Beds, Dolgelly. British Museum, I 7558 (fig. 4), I 7561 (fig. 5), I 7556 (fig. 6). (Belt Collection.)

7. Tail. Lower Lingula Flags, Cae Gwernog, Mawddach Valley. Sedgwick Museum.

Olenus gibbosus (Wahlenberg). 54

8. Nearly complete specimen, showing the lateral spine on the margin of the tail. Lower Maentwrog Beds, Dolgelly. British Museum, I 7546. (Belt Collection.)

9. Head and part of thorax. Lower Maentwrog Beds, Dolgelly. British Museum, I 7548. (Belt Collection.)

10. Head. Lower Maentwrog Beds, Dolgelly. British Museum, I 7538. (Belt Collection.)

Olenus micrurus, Salter. 55

11, 12. Salter's types. Lower Lingula Flags, Trawsfynydd. Museum of Practical Geology, 8948. (Both specimens are on the same slab of rock, and both are in the form of external moulds. The figures are drawn from artificial casts of these moulds.)

Olenus cataractes, Salter. 56

13. Probably Salter's type. Lower Lingula Flags, Treflys, Criccieth. Museum of Practical Geology, 8946.

14. Complete but distorted specimen. Lower Lingula Flags, Caen-y-coed Quarry, Maentwrog. Sedgwick Museum. (The counterpart of this specimen is in the Museum of Practical Geology, 8879.)

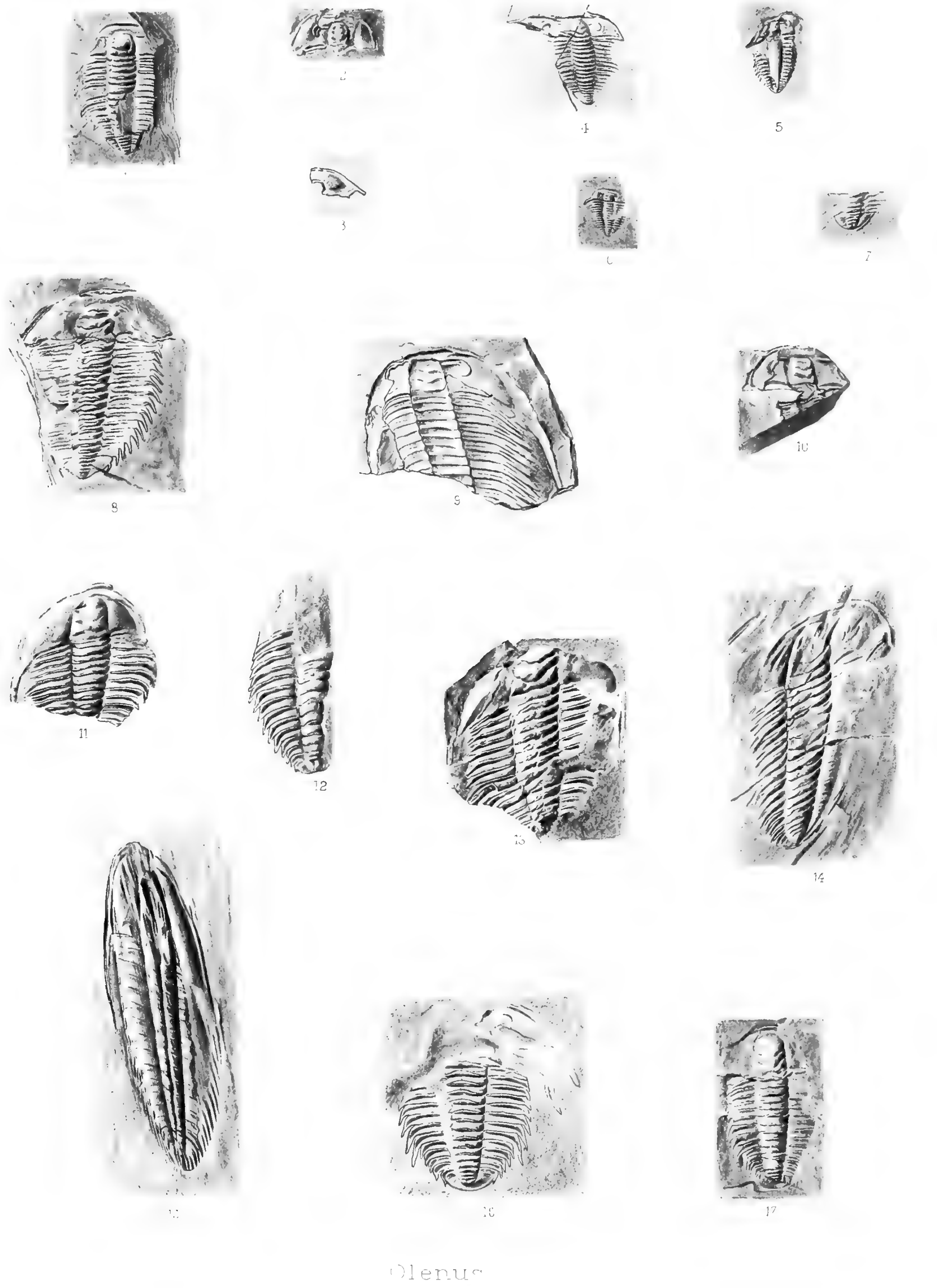
15. Specimen distorted by cleavage, apparently with long thoracic and pygidial spines. This appearance is due to wrinkling of the surface of the slate. Lower Lingula Flags, Caen-y-coed Quarry, Maentwrog. Sedgwick Museum.

16. Thorax and tail. Lower Lingula Flags, Trefgarn Bridge, Haverfordwest. Collected by Mr. V. M. Turnbull. Museum of Practical Geology, 22715.

17. Specimen showing fourteen thoracic segments. Lower Lingula Flags, Trefgarn Bridge, Haverfordwest. Collected by Mr. V. M. Turnbull. Museum of Practical Geology, 22717.

All the figures on this plate are drawn natural size.

Lake Cambrian Trilobites. PLATE V



Olenus

PLATE VI.

FIGS. | PAGE.

Olenus cataractes, Salter. 56

1. Specimen showing the points of the thoracic pleuræ. The last thoracic segment appears to be fused with the tail, which accordingly bears two spines on the left-hand margin, instead of one. Lower Lingula Flags, Trefgarn Bridge, Haverfordwest. Collected by Mr. V. M. Turnbull. Sedgwick Museum. Nat. size.

Olenus mundus, sp. nov. 58

2, 3. Forms supposed to be adult. Lower Lingula Flags, Trefgarn Bridge, Haverfordwest. Collected by Mr. V. M. Turnbull. Sedgwick Museum. × 4.

4, 5. Young forms. Lower Lingula Flags, Trefgarn Bridge, Haverfordwest. Collected by Mr. V. M. Turnbull. Sedgwick Museum. × 20.

Olenus longispinus (Belt). 60

6. Probably one of Belt's types. Locality uncertain (labelled *Conocoryphe bucephala*, Upper Ffestiniog Beds, Dolgelly; but the name and probably the horizon are incorrect). British Museum, I 7592. (Belt Collection.) × $1\frac{1}{2}$.

7. A shellac cast of a specimen now unknown. Upper Dolgelly Beds, Dolgelly. British Museum, I 7577. (Belt Collection.) × $1\frac{1}{2}$.

Parabolina spinulosa (Wahlenberg). 62

8. A rather small specimen. Upper Lingula Flags, Rhiwfelyn. Mr. G. J. Williams' Collection. (Drawn from an artificial cast of the specimen, which is an external mould.) × $1\frac{1}{2}$.

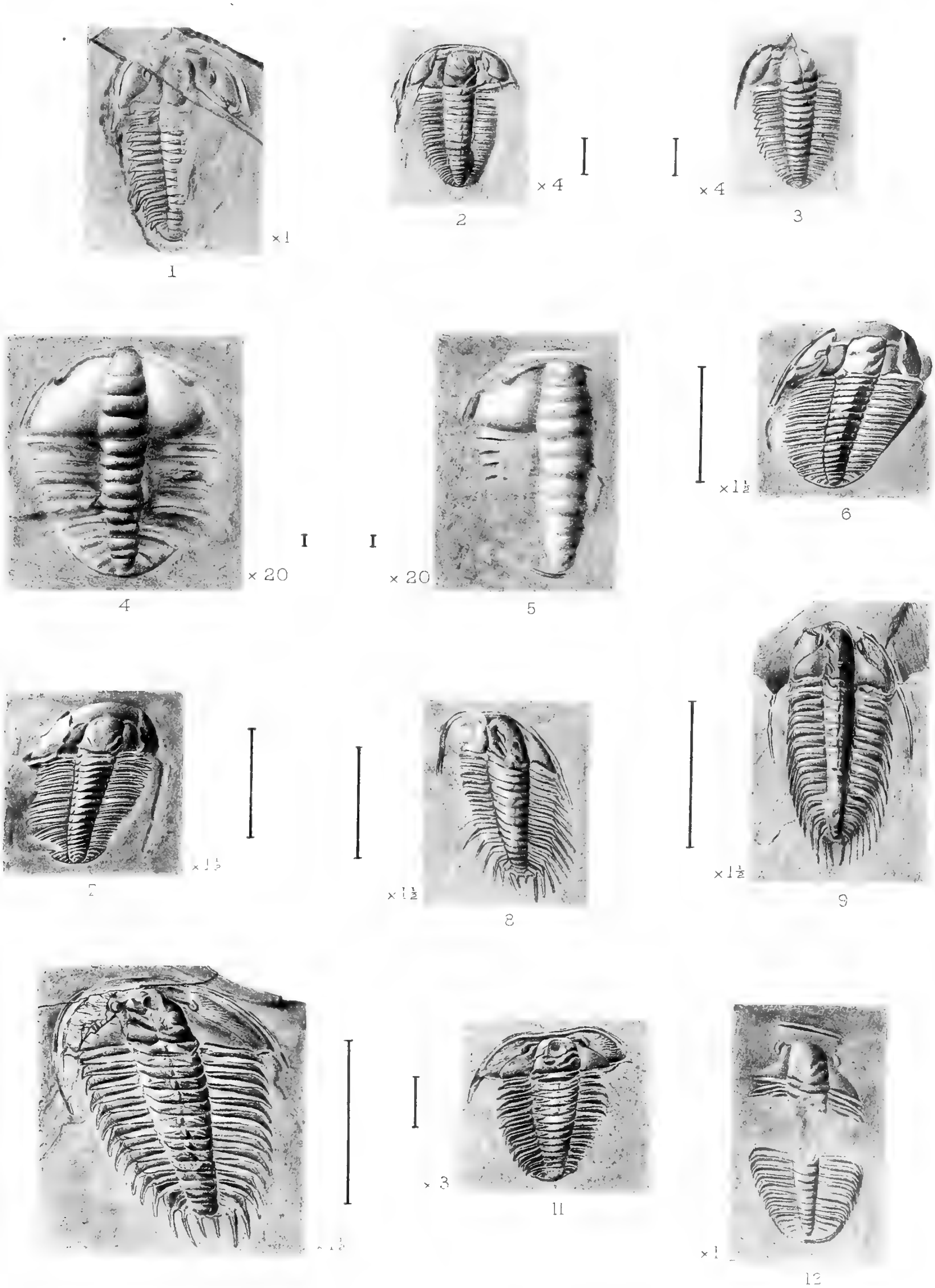
9. Specimen of about the average size. The two points behind the axis of the tail are present but indistinct. Lingula Flags, Rhiwfelyn. Mr. G. J. Williams' Collection. × $1\frac{1}{2}$.

10. Broad form. Upper Lingula Flags, Nant Cistfaen, Llyn Tryweryn. Mr. G. J. Williams' Collection. × $1\frac{1}{2}$.

11. Small form with very short pleural spines, probably young. Upper Lingula Flags, Llyn Tryweryn. Mr. G. J. Williams' Collection. × 3.

Parabolinella williamsoni (Belt). 64

12. Cranidium, parts of thorax, and tail, probably in their natural relative positions. Upper Lingula Flags, Moel Gron. Sedgwick Museum. (Drawn from an artificial cast of the specimen, which is a mould. The counterpart of the specimen is in the British Museum, 59291. Figured by Mr. F. R. C. Reed as *Olenus* [*Parabolinella*] *planti*, Geol. Mag., 1900, pl. xii, fig. 1.) Nat. size.


×1
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2
×4
3
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4
×20
5
×1½
6
×1½
7
×1½
8
×1½
9
×3
11
×1
12

Palæontographical Society, 1908.

A MONOGRAPH

OF

BRITISH GRAPTOLITES.

BY

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PART VII.

Pages cxxi—cxlviii, 273—358; Plates XXXII -XXXV.

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another—whether the different individuals have been developed by budding from the cœnosarc, or whether they are developed from, and connected with the one immediately preceding—must be considered to begin already in the sicula, even if it has been convenient, for the sake of description, to distinguish one part as the 'connecting canal.'"

The "*connecting canal*," as defined by Holm, is the canal which "arises almost simultaneously with the left theca and the common canal for the left half of the polypary," and which "crosses the dorsal side of the sicula and gives rise to the third theca and the common canal for the right half of the polypary." (This canal is not the same as that for which Törnquist used the term "connecting canal," and Törnquist has later proposed the name "crossing canal" for Holm's structure.)

The *Virgula.*—His observations lead him to the conclusion that "a virgula corresponding to that in *Diplograptus* and *Monograptus* cannot occur in the Dichograptidæ," at any rate "embedded in the dorsal side of the branches." Even in those cases in which the "sicula is embedded in the polypary, a virgula need not of necessity be present," and Holm fails to find any trace of one in *Phyllograptus.*

He points out that the "cylindrical chitinous thread which originates as a result of growth within the apertural end of the sicula" in *Diplograptus*, etc., as described by Wiman, "stands evidently in no relation whatever to the real virgula, but may be regarded as an apertural spine." And he draws especial attention to the fact that "the presence of a virgula has hitherto been considered as the main character of Graptolites" (Rhabdophora), "although such was never described or expressly mentioned except in the groups Diplograptidæ, Monograptidæ, and Retiolitidæ."

The structure of *Didymograptus minutus*, *D. gracilis*, and *D. gibberulus* is described in detail.

The genus *Tetragraptus*, of the development of which little was known, is shown by Holm to pass through the same early stage as a *Didymograptus* ("*Didymograptus* stage"). The four stipes arise by a "direct splitting of the common canal by a vertical wall" on each side of the connecting canal. This structure is worked out in specimens of *T. Bigsbyi.*

The development of the genus *Phyllograptus* is proved to be practically identical with that of *Tetragraptus*, but the branches, instead of having "four independent periderm walls, form a single, cruciform, four-winged, longitudinal septum." The sicula is embedded in the polypary, but no virgula has been detected.

This memoir is illustrated by excellent figures.

The second important paper, published in 1895, was by Wiman, and was perhaps even more far-reaching in its results.

The author commences with an account of the methods adopted by him for preparing the specimens examined.

1895. *Wiman,* "Ueber die Graptoliten," 'Bull. Geol. Instit. Upsala,' art. no. 6.

He next discusses certain controversial points with reference to the work of Törnquist and Holm. He accepts the facts obtained by Törnquist, and considers that their differences of opinion concern questions of terminology only.

By the term "theca" he means "a part of the test of a bilaterally symmetrical animal," and he repeats that "the individuals corresponding to the thecæ were developed from other similar individuals, and not from a substance contained in any common canal." "This," he writes, "is not only clear from the course of the growth-lines," but receives additional support from the recent discoveries made by himself as to the structure of the Dendroidea, in which there is no common canal.

He acknowledges the correctness of Törnquist's view that there is possibly always a longitudinal septum in *Diplograptus.*

He agrees generally with Holm as to the structure of *Didymograptus*, but considers it advisable to retain the word "sicula," though he regards it as probably the first theca, and he accepts Holm's view that the apical part of the sicula is the initial part and the youngest.

Wiman then gives a classification of the Graptolitidæ in general. This agrees in essentials with that proposed by Lapworth (1873), but is modified in some particulars.

The family of the Monograptidæ is first described, and the typical structure of a *Monograptus* is exemplified in *Monog. dubius*, *M. lobifer*, and *M. discus*.

He places the genus *Azygograptus* in the family of the Monograptidæ on account of its having only one row of cells, but he considers it to be a *Didymograptus*-like form in which one branch is missing and that it probably belongs to the Dichograptidæ, with which it is also contemporaneous.

Dimorphograptus may be considered as a transition form between the Diplograptidæ and the Monograptidæ.

The Dichograptidæ he divides into two sub-groups according as they resemble *Didymograptus* or *Tetragraptus.*

He points out that in *Didymograptus* the opening between the sicula and the first theca may not only occur on the initial or the apertural part, but may occupy very different positions on the bilaterally symmetrical sicula.

In the Graptoloidea he believes there is no "essential difference" between monopodial and dichotomous branching, though in the Dendroidea it would have more significance.

Wiman attaches considerable importance to Hopkinson's discovery of partition walls in *Tetrag. serra* between the common canal and the thecæ, and he indicates the analogy between this structure and that in the Dendroidea. He suggests that the "Graptoloidea are only the most superficial periderm of the Dendroidea": "the proximal projections of the thecæ in the Dendroidea, which fill the common

canal with many delicate tubes," were "still thinner in the Graptoloidea and less likely to be preserved, so that they have almost entirely disappeared, and have only exceptionally left behind traces of their existence."

The structure of the Diplograptidæ is next discussed, and *Diplograptus* **uplandicus,** n.sp., and *Climacograptus Kuckserianus,* Holm, are taken as examples. An interesting new form—*Climacog.* **retioloides**—is also described.

The family of the Phyllograptidæ is retained by Wiman with full knowledge of the demonstrations of Holm that its structure is essentially similar to that of *Tetragraptus.*

The histology of the Graptolite periderm is next discussed, and Wiman concludes that in *Monograptus* there are only three layers, a middle thick one and a thin one on each side of it.

Retioloidea.—In the group of the Retioloidea Wiman gives a full description of the structure of *Retiolites nassa.*

Dendroidea.—The latter part of Wiman's paper is of especial interest, containing many new facts of far-reaching importance connected with the group of the Dendroidea.

Wiman shows by means of sections that "in all Dendroidea there can be distinguished three different kinds of individuals: *nourishing individuals* (which he also calls thecæ, since they doubtless correspond to the thecæ in the Graptoloidea), *budding individuals,* and *sexual individuals* or *gonangia.*"

The Dendroid structure is described in great detail in the case of several species and genera of the Dendroidea. In all cases the budding individual never opens to the exterior, but itself gives rise to three new individuals, and these, as they grow, gradually fill up the whole of the cavity of the mother budding theca.

The species described include *Dictyonema* **rarum,** *D.* **peltatum,** *D.* **tuberosum,** and *D. flabelliforme. Dendrograptus* (?) **œlandicus,** *D.* (?) **balticus,** *D.* (?) **bottnicus,** and *Ptilograptus* **suecicus.**

The method of branching in the Dendroidea is carefully worked out in *Dendrog.* (?) *œlandicus.*

In *Ptilograptus suecicus* the structure is somewhat different. "The branches carry twigs" which spring out alternately to right and left, and "these consist of four individuals, opening one after the other."

The mode of growth of these various forms of Dendroidea is very different, some having a sicula, others having a disc from which a stem proceeds. In *Dictyonema peltatum* "a large number of branches spread centrifugally within a disc," and then rise up, "branch, anastomose, and join again by means of the ordinary connecting fibres." "The proximal ends of the branches" in this species do not "possess the intricate structure that characterises the distal parts," and resemble those in a *Monograptus.*

Wiman shows clearly from the foregoing that the older generic diagnoses of the

Dendroidea, drawn up as they were when practically nothing was known of their structure, are now of little value, but he admits that a new classification would as yet be impracticable and inadvisable.

As respects the systematic position of the Graptolites he considers that it is impossible to say more than that the "Graptolites are bilaterally symmetrical Invertebrates."

Phylogeny.—Wiman discusses the relationship between the Graptoloidea and the Dendroidea, and considers that "they are two parallel stocks of equal value in which the division of labour is performed in somewhat different ways." "In the Graptoloidea the different functions (while all the individuals of the first order remain the same) are shared among different organs." "In the Dendroidea, on the other hand, the different functions are shared by three different forms of individuals of the first order."

The theory that the Graptoloidea are descended from the Dendroidea seems to him very improbable; while the reverse idea, namely that the Dendroidea are descended from the Graptoloidea, meets with greater favour, as it is usual for "division of labour in a colony to bring about a difference of individuals."

The mode of life of the Graptolites is next dealt with, and Wiman concludes that the only possible view to take is that "the Graptolites, in some way or other, stood upright" and lived in the "deeper littoral regions."

The paper concludes with an Appendix giving an abstract of Ruedemann's discoveries of colonies of *Diplograptus* attached by their virgulas, and some of the points referred to there are discussed and criticised. Exception in particular is taken to Ruedemann's idea that these colonies were provided with a swimming bladder.

1895.
Ruedemann,
"Synopsis of the Mode of Growth and Development of the Graptolitic genus *Diplograptus*," 'Amer. Journ. of Sci.,' ser. 3, vol xlix, no. 294.

Considerable light had already been thrown on the mode of life and development of the Diplograptidæ by Ruedemann's discovery of some remarkable specimens of forms referred by him to *Diplograptus pristis* and *Diplog. pristiniformis* (afterwards named *Ruedemanni*). The first notice of this was given in an abstract published by him in the American Journal of Science.

Ruedemann summarises his conclusions as follows:

(1) These two species grow in "compound colonial stocks which appear in the fossil state as stellate groups."

(2) "The virgulæ are joined to a central connecting stem, the 'funicle' of Hall, which is mostly extended to a vesicle of quadrangular shape." The funicle is "enclosed in a central disc" which is a "thick, chitinous capsule" also quadrangular in shape.

(3) "The central disc is surrounded by a verticil of oval capsules," in number four to eight or more. Some of these oval appendages are seen to contain siculæ

"which radiate from an axial club-shaped protuberance within the vesicle, to which they are joined by the filiform prolongation of their pointed ends." Ruedemann compares these vesicles with the gonangia of recent Hydrozoa.

(4) Overlapping the gonangia and even the proximal ends of the stipes, there is an organ which he compares with the air-bladder or pneumatocyst of the Discoideæ and which he regards as having acted as a float.

(5) The siculæ "at the time of developing the first two hydrothecæ, possess a quadrangular plate, joined by a small node in the centre to the end of the filiform proximal process"; while at a slightly later stage of development four oval impressions can be seen around the central node. This quadrangular plate (or probably vesicle) develops into the pneumatocyst, the central node into the funicle and central disc, and the small oval impressions probably indicate the gonangia.

(6) From the position of the siculæ at the remote end of the stipes the "so-called proximal sicula-bearing end of the single stipes appears in the compound colonial stock as the distal one." "The stipe grows backward towards the centre and the sicula is carried to the distal end."

(7) With regard to the affinities of the Graptolites, Ruedemann points out that by the "possession of a pneumatocyst and the arrangement of the reproductive organs at the bases of the stipes, the colonial stocks of *Diplograptus* had a general similarity to those of certain Siphonophora, while the chitinous structure of the hydrothecæ and gonangia can be only referred to the Sertularians."

1895.
Matthew, G. F., "Two new Cambrian Graptolites with Notes on other Species of Graptolitidæ of that Age," 'New York Acad. Sci. Trans.,' August 29th.

Matthew described in 1895 some new species of *Clonograptus*, *Bryograptus*, etc., from the lower part of Division 3 of the St. John Group. *Clonograptus* **proximatus**, sp. nov., resembles *Clonog. tenellus* in many respects; unlike the latter it occurs in association with *Dictyonema flabelliforme* and not above it. Matthew distinguishes *Clonograptus* from *Bryograptus* by its being "devoid of the sicula, or with the sicula obscure, absorbed, or merged in the funicle." Four species of *Bryograptus* are described and figured: *Bryog.* **patens**, *B.* **spinosus**, *B.* **lentus**, *B.* **retroflexus?** A fragment of *Callograptus* is figured and two specimens of *Dictyonema flabelliforme*, showing "short rootlets developed from the proximal end of the sicula." As regards the occurrence of the last-named form in America, Matthew states that the species was not a "solitary Graptolite," as in some parts of Europe, but was associated sparingly with *Bryograptus* and *Clonograptus*.

As to the phylogenetic relationships of the Graptolites he writes, "the succession of the Dichograptidæ in the Cambrian and Lower Ordovician is a good exemplification of increased condensation of structure due to selection; for the many-branched forms of the former are gradually replaced by the *Tetragrapti* and these by the *Didymograpti* of the Upper Arenig." He repeats his former view that the *Bryograpti* were the ancestors of *Dictyonema*.

1895. *Lake*, "The Denbighshire Series of South Denbighshire," 'Quart. Journ. Geol. Soc.,' vol. li.

During the same year Lake noted the existence of both a Wenlock and Lower Ludlow Graptolitic fauna in the Denbighshire series of S. Denbighshire.

1895. *Perner*, "Études sur les Graptolites de Boheme," pt. ii; "Monographie des Graptolites de l'Étage D."

The second part of Perner's work on the Bohemian Graptolites, including the species found in Étage D, was published in 1895. Several new species are described and figured, but owing to the poor state of preservation and fragmentary condition in which these are found in Bohemia, any certain identification of them is a matter of difficulty. The following are described and figured:

Dichograptus (*?*) **leptotheca**, n. sp.

Tetragraptus caduceus.

Didymograptus.—(Group A)—*D. bifidus*, *D. Murchisoni*, *D. denticulatus*, *D.* **oligotheca,** *D. indentus* var. *nanus*, *D.* **spinulosus,** *D.* **clavulus,** *D.* **Barrandei,** *D.* **Lapworthi,** *D. bifidus* var. **incertus,** *D.* **vacillanoides.** (Group B)—*D. v-fractus.* (Group C)—*D. pennatulus*: *D.* **linguatus,** *D.* **lonchotheca,** *D. pennatulus* var. **hamatus,** *D.* **retroflexus.**

Dicellograptus anceps.

Cryptograptus tricornis.

Climacograptus tectus.

Diplograptus pristis, *D. euglyphus* var. **angustus,** *D.* **lobatus,** *D.* **lingulitheca,** *D.* **terres,** *D.* **insculptus,** *D. rugosus* var. **Fritschi,** *D. truncatus*, *D. foliaceus* var. *vulgatus.*

Dendrograptus constrictus.

A table is given showing the range of each species.

A useful list of works published on the Graptolites in general and an historical account of the Graptolites in Bohemia, are prefixed to this second part of Perner's work.

1895. *Nicholson and Marr*, "Phylogeny of the Graptolites," 'Geol. Mag.,' dec. 4, vol. ii.

An important paper bearing on "The Phylogeny of the Graptolites" was published by Nicholson and Marr in 1895. The authors conclude (1) that "the character of the hydrothecæ is the most important point to retain in view in separating different families of the Graptoloidea"; and (2) that the next most important point as "indicating genetic relationship," is the angle of divergence of the stipes; while the number of stipes, on which the present classification of the Graptolites largely depends, is relatively insignificant.

In consonance with these conclusions, the authors take the eight known species of *Tetragraptus*, and group round each of them those species of *Dichograptus*,

Bryograptus and *Didymograptus* which agree with them most closely in the character of the thecæ and the "angle of divergence." Group 1 contains *Bryograptus Callavei*, *Tetrag. Hicksii*, and *Didymog. affinis*; Group 3 *Bryog. ramosus*, *Tetrag. fruticosus* and *Didymog. Murchisoni*; Group 6 *Tetrag. Bigsbyi*, *Didymog. gibberulus*, and an unknown *Dichograptus*, and so on. In those cases where, in any corresponding place in a given group, there is no species with the required characters to fill the gap, the authors confidently assert that further research will probably reveal its existence. The authors hold that the members of each of these groups are phylogenetically related, and that it is very difficult to understand how the "extraordinary resemblances between the various species of *Tetragraptus* and *Didymograptus* have arisen, if, as usually supposed, all the species of these genera have descended from a common ancestral form for each genus, in the one case four-branched, in the other case two-branched;" "on the other hand, it is comparatively easy to explain the more or less simultaneous existence of forms possessing the same number of stipes, but otherwise only distantly related, if we imagine them to be the result of the variation of a number of different ancestral types along similar lines." They suggest that the genus *Monograptus* also may contain "descendants of more than one family."

The authors point out that if their conclusions are correct, the present nomenclature would have to be eventually altered. Meanwhile they propose to retain such names as *Monograptus*, *Didymograptus*, etc., as "generic" names, but the "species placed under these different groups do not belong to definite genera" (in the strict biological sense of the word): they constitute cases of what Buckman terms the "hetero-genetic homœomorphy" of forms which are only distantly allied to one another.

They adduce briefly reasons for this "special case of mimicry, and endorse Clement Reid's suggestion that the variations in form may be connected with the supply of food"; the necessity of providing food brought about a reduction in the number of stipes, and also a change in the direction of these stipes. Those series of hydrothecæ which were farthest apart would have a better chance of obtaining food, and thus the "angle of divergence" increased from a very small angle until it reached its maximum of 360° in *Phyllograptus*, *Diplograptus*, etc. Variations in the form of the hydrothecæ may also be explained on the same ground.

In a note to this paper, Nicholson and Marr suggest the new specific name of *Tetragraptus* **inosculans** for those forms which resemble *Tetrag. Bigsbyi*, but in which the stipes are in contact or even more or less fused.

1895.
Hall,
"Notes on *Didymograptus caduceus*, with remarks on its synonymy," 'Proc. Roy. Soc. Victoria,' vol. viii.

T. S. Hall discussed at considerable length the question of the synonymy of *Didymograptus caduceus* in a paper published in 1895. He concludes that Salter's name *D. caduceus* has priority over *D. gibberulus*, and therefore the latter should fall out of use.

1896. *Ruedemann*, "Development and Mode of Growth of *Diplograptus*," 'N. Y. State Geol. Annual Report' for 1894.

Ruedemann's preliminary notice on the development of *Diplograptus* was followed about a year later by a more complete paper fully illustrated. His previous views are here repeated and amplified, but in a few cases they are somewhat modified as the result of a further investigation of additional material.

With regard to the general form of the complete frond of *D. pristis* and *D. Ruedemanni*, which consists of many stipes arranged so as to radiate outwards from a central point—the funicle, these stipes are of three different lengths, and are connected together to an approximate central form by their virgulas, "or more properly hydrocauli." Ruedemann distinguishes between the virgula proper and the hydrocaulus, "which forms the connecting stem and is a canal containing the virgula of the rhabdosome included in its distal part."

As to the function of the central disc "which encloses the funicle," it may have served to support the bases of the stipes, it was "certainly a protection to the funicle," and it may have served as a float.

The *basal cyst* consists of "two segments resting in the middle on both sides of a subquadrate base, and the test is comparatively thin. The gonangia and rhabdosomes which proceed from the central disc and funicle, occur below the basal cyst. Ruedemann at first regarded this organ as a "float" or swimming bladder, and believed that the Graptolites floated, on account of (1) the extreme length and thickness of the hydrocaulus in some specimens, which "makes it difficult to imagine how such an extremely thin stem could have supported the long and broad rhabdosome in any other than a suspended position"; (2) the absence of any evidence of the sessile nature of the colonies; and (3) their wide distribution, which would be accounted for by their floating habit. This view of their floating habit, however, Ruedemann relinquished in this second paper, on account of the discovery of a large slab in which more than a hundred colonies of *D. Ruedemanni* are spread out regularly. He considers that the "improbability of such an array of nicely ordered, apparently undisturbed stellate groups having been drifted together is obvious." The hydrocauli and rhabdosomes possess only a very slight flexibility, and therefore it was only where there were no currents in the sea that one could hope to find entire colonies.

He abandons the floating theory previously held by him, and suggests that the basal cyst was "buried in the detritus" on the floor of the ocean, and served to procure stability for the colony.

He compares the gonangia or vesicles containing the siculæ with certain organs in the Sertularians, and considers that they resemble in all the more important features the Sertularid gonangium, which contains a cylindrical column, the "blastostyle," and he thinks that the possession of these organs and also their structure are arguments for the hydrozoan nature of the Graptolites.

Ruedemann next discusses briefly the various supposed reproductive organs described by previous authors, and suggests that the "bi-thecæ" observed by Holm in *Dictyonema* should rather be compared with the nematophores of the Plumularians than with gonangia.

He deals with the development of the sicula at some length, and considers that while there is "conclusive" evidence that numerous siculæ left the gonangia, it is also clear that others did not sever their connection with the parent colony, but grew out into new rhabdosomes.

The development of *Diplog. pristis* is worked out by him in detail, and his results may be summarised as follows:

(1) The detached sicula is attached by means of a small round node to a basal appendage.

(2) The hydrocaulus gradually lengthens and more and more thecæ are formed.

(3) "The node becomes the central disc and funicle. The sicula produces at first one theca, then a second, third, etc."

(4) The growth of the gonangia (four small capsules) begins with the budding of the first thecæ.

(5) The gonangia mature and open, the siculæ, however, remaining connected with the parent colony, the basal cyst, funicle, etc., are all present.

(6) The siculæ grow out to rhabdosomes.

(7) A second generation of gonangia begin to grow, and the process is continued.

The "number and length of the rhabdosomes increase with the age of the whole colony."

Affinities.—As respects the affinities of the Graptolites, he merely states that they should be placed in a distinct class—the Rhabdophora.

He concludes his paper with a reply to some of the objections raised by Wiman, especially with regard to the terms employed for the various structures. He maintains that the "central discs" of *Dichograptus* and *Diplograptus* are "genetically identical," but he relinquishes the employment of the term "funicle" for the connecting stem of *Diplograptus*. He argues also in favour of the "gonangia"-like nature of the capsules described by him.

1896.
Gürich,
"Bemerkungen zur Gattung *Monograptus*," 'Zeitsch. d. deutsch. geol. Gesell.,' vol. xlviii.

In the same year, 1896, Gürich published a paper, "Remarks on the genus *Monograptus*," in which he discussed the structure, the shape of the thecal aperture, and also the biology of the Monograptidæ in general.

As regards the histology of the Graptolite skeleton, he recognises the four structural layers described by Perner, but considers that the appearances are capable of a different explanation. He adds many new facts regarding these, and considers that the layer "with coigns" is "not the organic structure of a special

layer of the rhabdosome wall, but a peculiar calcite deposit formed during the process of fossilisation, the formation of which was only possible when the skeleton of the rhabdosome wall—namely the black layer—was surrounded by an organic integument."

The "palisade" layer (layer with colonnettes) he also regards as another form of the calcite deposit surrounding the black layer. Gürich concludes from his investigations that the chitinous skeleton of the rhabdosome in the living condition was surrounded by a skin, but that it is impossible to say of how many layers this skin consisted, or what were their particular histological peculiarities. The existence of such an outer skin is proved by the presence of growth-lines, and the chitinous skeleton, instead of being external, is mesodermal. These conclusions of Gürich are in accordance with Wiman's views ('Ueber die Graptolithen,' 1895).

The form of the aperture in *Monograptus priodon* is dealt with, and Gürich disputes Jaekel's idea of a laterally expanded projection, pointing out that the theca in this form is merely a "tube whose open oval end is bent back towards the sicula." He gives a figure showing a schematic reconstruction of the cells of this species.

The paper concludes with remarks on the mode of life of the Monograptidæ. He considers that it is very improbable that they were attached to the sea floor, and argues that their geological distribution, their method of preservation, etc., speak in favour of their being Plankton.

Ruedemann's discovery of colonies of *Diplograptus* justifies us, he considers, in concluding that the Monograptidæ possessed a swimming bladder, and also that a large number arose from one and the same stock. In this case the relationship between the rhabdosome, sicula and disc becomes of primary importance, the form of the aperture is secondary, and is the result of such a relationship. He refigures and discusses his schematic representation of the differences between the *Monograptus erecti* and *M. reversi* groups.

1896.
Gurley,
"North American Graptolites," 'Journ. Geol.,' vol. iv, no. 1.

In 1896 Gurley published a paper entitled "North American Graptolites," in which he gives a complete list of American forms, discusses the synonymy of many of the genera and species, and describes a large number of new species, without, however, figuring them.

Description of Species.—The following forms are referred to or described: *Phyllograptus?* **cambrensis,** *Bryograptus?* **multiramosus,** *Dichograpsus* **remotus,** *D. abnormis, Tetragrapsus* **acanthanotus,** *Didymograpsus* **bipunctatus,** *D.* **perflexus,** *D. geminus, D. hirundo, D.* **convexus** and *D.* **sagitticaulis.**

The generic name *Stephanograptus* should, he considers, take precedence of *Helicograptus* and *Cœnograptus*: two new species are described: *S.* **crassiusculus** and *S.* **exilis.** *Azygograptus* is represented doubtfully by one species *A.? Walcotti.*

Other forms noted are *Leptograptus?* **macrotheca,** *Dicellograptus intortus* var. **polythecatus,** *D.* **Gurleyi,** *D. elegans; Dicranograptus furcatus, D. Nicholsoni,* var. **arkansensis,** var. *whitianus,* var. **parvangulus,** var. **diapason;** *Climacograptus antiquus, C. caudatus,* var. **laticaulis,** *C.* **oligotheca,** *C. cœlatus, C.* **phyllophorus;** *Diplograpsus stenosus; Glossograptus* **arthracanthus;** *Lomatoceras* (he thinks that this name has clear priority over *Monoprion* or *Monograptus,* and so far as he can ascertain has never been used for the name of an insect); *Gladiolites* (instead of *Retiolites*) *venosus; Reteograptus Geinitzianus; Dictyonema cf. neenah, D.* **perexile,** (=*D. delicatulum,* Dawson, preoccupied), *D.* **actinotum,** *D.* **Blairi;** *Desmograptus* **macrodictyum,** *D.* **devonicus;** *Dendrograptus* **unilateralis,** *D.* **arundinaceus,** *D. cf. serpens.*

Gurley describes three species of *Caryocaris* which "from its resemblance to *Dawsonia* may be a Graptolite"; the species are *C. Wrightii, C.* **oblongus,** and *C.* **curvilatus.** *Dawsonia* is represented by two new species: *D.* **monodon** and *D.* **tridens.** A new genus—**Phycograptus**—is proposed and two species of this genus are described: *P.* **brachymera** and *P.* **lævis.** *Thamnograptus Barrandii* is also referred to, and it is suggested that the "thecæ appear to have been excavated out of the substance of the branch."

1896.
Gurley,
"North American Graptolites," 'Journ. Geol.,' vol. iv, no. 3.

The second part of this paper, which was published three months later, deals mainly with the "Vertical Range of the Graptolites in America," and detailed tables are given, showing their distribution and range.

In addition, a new species is described, viz. *Diplograpsus* **Ruedemanni,** being one of the forms mentioned by Ruedemann as *D. pristiniformis* in his paper on the "Mode of Life of the Graptolites."

1896.
Elles and Wood,
"On the Llandovery and Associated Rocks of Conway," 'Quart. Journ. Geol. Soc.,' vol. lii.

In 1896 Elles and Wood recorded the existence of an Upper Birkhill graptolitic fauna at Conway, North Wales, including the zone of *Rastrites maximus.* They also found representatives of the faunas characteristic of the overlying Tarannon and Wenlock Shales.

1896.
Hall, T. S.,
"On the Occurrence of Graptolites in North-Eastern Victoria," 'Proc. R. S. Victoria,' vol. ix (new series).

In the year 1896 T. S. Hall recorded the existence of Ordovician Graptolites from two or three localities in North-Eastern Victoria.

He considers that judging from the species of *Dicellograptus, Dicranograptus, Diplograptus* and *Climograptus* identified by him the beds appear to belong to the "higher part of the Ordovician."

In 1896 Wiman published the results of his researches on the structure of the Dendroidea by a paper on a new species of *Dictyonema*—**D. cavernosum.**

1896.
Wiman,
"Ueber *Dictyonema cavernosum,*" 'Bull. Geol. Inst. Upsala,' vol. iii, art. no. 1.

He gives special attention to the structure of the proximal end and shows how the first thecæ originate from the disk of attachment ("haftscheibe").

By means of cross sections he finds that two individuals of different sizes appear to arise from the disc of attachment, and he gives various explanations as to their origin. He inclines to the view that the larger individual was the older and was originally free-swimming, and that from it the smaller budding individual was developed. Another explanation which he considers probable is, that both thecæ were produced from an older and non-chitinous individual which was originally free-swimming.

1897.
Törnquist,
"On the Diplograptidæ and the Heteroprionidæ of the Scanian *Rastrites* Beds," 'Acta Reg. Soc. Physiog. Lund.,' vol. viii.

In 1897 Törnquist published the first part of his Monograph on "The Graptolites of the *Rastrites* Beds." In this he deals with the Diplograptidæ and the Heteroprionidæ, and describes and figures several species of *Diplograptus* and *Climacograptus*, some of which are new to science.

Description of Species.—The descriptions and illustrations are excellent, and are specially concerned with the elucidation of the detailed structure of the proximal end, which had previously remained almost unnoticed. The species described include the well-known forms: *Climacograptus scalaris, C. rectangularis, C. undulatus, Diplograptus palmeus, D. folium, D. acuminatus, D. cometa, D. tamariscus, D. bellulus, D. longissimus,* and in addition two new species: *Climacog.* **medius** and *Diplog.* **cyperoides,** and a new varietal form, *Dimorphog. Swanstoni* var. **Kurcki.**

Törnquist considers that "at present it is advisable to retain the genus *Diplograptus* undivided," and he therefore does not adopt the sub-generic names of *Petalograptus* and *Cephalograptus.*

Terminology.—Törnquist discusses various questions of terminology, and endeavours to bring the nomenclature employed by Wiman, Holm and himself into uniformity. He considers that the terms "obverse" and "reverse" aspects are liable to less ambiguity than those of "sicula" and "anti-sicula" side, and he also prefers the names "primary" and "secondary" to the "left" and "right" for distinguishing between the two series of thecæ. He proposes the term "prolific side" for that side of the sicula which "communicates with the proximal cavity of the rhabdosome." The opposite side he calls the "dorsal" side.

He also suggests the new name "virgella" for the "so-called proximal prolongation of the virgula."

He discusses in some detail the question of the exact application of the words "thecæ" and "common canal," and thinks that the term "theca" is a convenient

one for that part of the common chamber "which is capable of being broken off." He therefore considers that it is "advisable to retain the word theca in its original sense," and if a new word be necessary, to give one to "that portion of the periderm which corresponds to an individual zooid once living within" (that is to say the theca and its contributory part of the common canal combined).

Although Törnquist agrees with Holm that the sicula is the covering of the first zooid, he considers it very advisable to distinguish "in practice, between sicula and thecæ," and therefore does not apply the term "first theca" to the sicula.

Range and Distribution.—Törnquist prefaces his paper with an account of the seven Graptolite Zones in the *Rastrites* Beds of Scania. These are very similar to those given by Tullberg, with the addition that the lowest zone, *i. e.* that of *Diplograptus acuminatus*, is here recognised in Scania for the first time.

1897.
Perner,
"Études sur les Graptolites de Boheme,"
Prague, pt. iii,
sect. *a.*

In 1897 Perner published the first section of the third part of his Monograph on the "Graptolites of Bohemia." This part contains a description of the species of Graptolites found in the lower layers of the band E. i., which corresponds to the Llandovery-Tarannon beds of England.

Description of Species.—In the genus *Diplograptus* Perner describes and figures the well-recognised species of *Diplograptus palmeus*, *D. bellulus*, *D.* (*Glyptograptus*) *vesiculosus*, *D. tamariscus*, *D. sinuatus*, *D. ovatus*, and *D. modestus*.

In the genus *Cephalograptus* he includes *C. cometa* and *C. folium*.

The genus *Climacograptus* comprises *C. phrygionius*, *C. scalaris*, and the new species *C.* **bohemicus.**

Rastrites is represented by *R. Linnæi* (= *R. fugax*, Barr.), *R. peregrinus*, including two new varieties, var. **longispinus** and var. **approximatus,** and a new species, *R.* **Richteri.**

The group of Leptopodes in the genus *Monograptus* includes *M. argutus*, *M. attenuatus*, *M. cyphus*, *M. limatulus*, and a new species, *M.* **tubiferus.**

In the group of the Orthopodes Perner describes *M. leptotheca*, *M. Hisingeri*, *M. crenulatus*, *M. Sedgwicki*, *M. Halli*, and a new variety of *M. jaculum*, *i.e.* var. **variabilis.**

The group of Helicopodes contains *M. planus* (= *M. resurgens*, Linnars.), *M. convolutus*, *M. proteus*, *M. triangulatus*, *M. turriculatus*, *M. communis* and a new species, *M.* **mirus,** Barr., sp. ms.

In the group of the Opisopodes, Perner discusses at some length the exact identity of *Monograptus Becki*, and shows that Barrande had confused three distinct forms, all from different zones, under this single specific name. He refigures the true *M. Becki* and also describes *M. lobiferus*, two new varieties (var. **Lapworthi,** and var. **undulatus**), *M. runcinatus*, *M. crispus*, *M. dextrorsus*, *M. distans*, *M. Clingani*, *M.* (*Rastrites*) *gemmatus*, and the following new species: *M.* **retusus,**

M. **Marri,** *M.* **Holmi,** *M.* **densus,** *M.* **Nicholsoni,** *M. Clingani* var. **tenera,** and var. **Hopkinsoni.**

The group of Kamptopodes contains *M. nuntius.*

The genus *Retiolites* is represented by *R. perlatus* and *R. obesus.*

1897. *Lapworth,* "Die Lebensweise der Graptolithen," in *Walther's* "Ueber die Lebensweise fossiler Meeresthiere," 'Zeitsch. d. deutsch. geol. Gesell.,' vol. xlix, Heft. 2.

In the year 1897, Walther, of Jena, published in the pages of the 'Zeitschrift der deutschen geologischen Gesellschaft' a memoir on the "Mode of Life of Fossil Sea Animals." This memoir includes (pp. 238–258) an article by Lapworth on "The Mode of Life of the Graptolites." In this, Lapworth dealt with this subject in the same comprehensive manner as he had already dealt with the classification of the Graptolites in 1873, and their distribution in 1879–80.

He adduces the facts known with reference to the relative distribution of the Graptolites in the various types of sediment within the British Isles, and shows that these facts go to prove that:

(1) The presence of Graptolites in any of our British rock-layers stands in some way related to the presence of carbonaceous matter in the sediments in which the Graptolites occur.

(2) Although Graptolites are found in all our Proterozoic sediments, yet they are normally and typically restricted to regions where much carbonaceous matter was deposited.

(3) The relative abundance of Graptolites in any single layer or rock-group is in some way connected with the calm of the sea-floor where the carbonaceous deposits were laid down (for the material in which the Graptolites lie embedded is usually so impalpable in grain that the gentlest current would have removed it); and that the most typical and richest British Graptolite-bearing beds are those which accumulated at the slowest rate.

It is next shown that the Graptolites themselves did not supply the carbonaceous matter in the sediments, nor did they live where they are now found. The carbon-producing organisms must also have been strangers to the locality, and it is inferred that these must have been floating sea-weeds.

The distribution of the black sediments and their thinness both point in the same direction; they are deposits formed mainly from the relics of floating sea-weeds, arranged in quiet waters parallel to the shore, having been drifted by currents and sinking when waterlogged to the bottom. The presence of Graptolites associated with these is in harmony also with the abundance of Hydroid organisms living on the fronds of the Sargassum sea-weed of the present day, which have been drifted from the shore, and become accumulated in special regions of the ocean or swept by currents into almost all latitudes.

These conclusions being conceded, we have what appears to be the clue to the mode of life and the general line of evolution of the Graptolites, including both

virgulate and non-virgulate forms. The Cladophora or non-virgulate forms, like the modern Sertularians and their allies, must have been fixed to rocks in the shallow parts of the sea-shore, and therefore stationary, or to floating objects of a comparatively large size. The Rhabdophora or virgula-bearing Graptolites, on the other hand, were attached to floating sea-weeds, and were therefore drifted far and wide over the waters of the sea at the mercy of winds and currents. The non-virgulate forms grew vertically upwards, and like their modern representatives, were more or less tree-like. The virgulate forms hung vertically downwards, being pendent to the under side of the sea-weed by a thread-like fibre, which in its earliest stages constituted the "nema" proceeding from the apex of the sicula, and which, in the later forms of the Rhabdophora, growing with the general growth of the rhabdosome, constituted the "solid axis or virgula." In other words the Rhabdophora form a special section of the Graptolites, modified for a pseudo-planktonic mode of existence. The modification commenced in later Cambrian times, within the limits of the genus *Dictyonema*. Some forms of this genus are provided with a short stem and a disc of attachment, and some examples, even of the same species, may have grown vertically, while others may have assumed a pendent position. Abundant examples, however, are met with in which the stem is lengthened out into a long, thread-like hydrocaulus or nema. In these forms the pendent mode of attachment is the only one possible. In harmony with this we find that once this change from dendroid to pendent is initiated, the Graptolites become world-wide in their distribution and remarkable for their abundance.

In the successive stages of the evolution of the Rhabdophora in time, the number of branches is gradually reduced, and they become turned more and more backwards and upwards towards the light. A first stage is typified by the oldest family (the Dichograptidæ), in which the nema is lengthened, and within the limits of which the branches bearing thecæ, originally turned downwards owing to their pendent position, turn in the successive genera backwards and upwards towards the line of the nema. The angle of divergence of the branches gradually increases thus from 0° to 360°, and in the Phyllograptidæ the branches, which by this time have been reduced to four in number, attach themselves to each other dorsally and grow backwards up the line of the nema, and the thecæ have practically recovered their upward direction.

In a succeeding stage (the Diplograptidæ) the branches are reduced to two in number, and the nema, which apparently lengthens with the growth of the organism, has become a typical virgula.

In the final stage (the Monograptidæ) the branches are typically reduced to one, and the evolutionary series is closed.

It is pointed out that difficulties exist, especially as regards the Dicellograpta (Leptograptidæ and Dicranograptidæ), but if it be accepted, even as a broad generalisation, that the typical nema- and virgula-bearing Rhabdophora were

pendent forms attached to floating sea-weed, this generalisation harmonises the previously known facts as respects their special mode of occurrence, their universal dissemination, their superabundance in carbonaceous deposits, their restricted geological range, and their broad lines of evolution in time.

1897.
Frech,
"Lethæa Geognostica," in continuation of Roemer's 'Lethæa Palæozoica,' vol. i.

In 1897 Frech published an extended monograph on the Graptolites in general, in his continuation of Roemer's great work 'Lethæa Palæozoica,' which was left unfinished at his death.

In addition to epitomising and illustrating the discoveries and conclusions of previous observers, Frech made many new theoretical suggestions, especially as regards the classification of the Graptolites.

Organisation of the Graptolites.

Frech commences with discussing the organisation of the Graptolites, dealing first with :

A. *Organisation of the Fully-grown Animal.*—Broadly speaking, he adopts the views of Ruedemann with relation to the so-called pneumatophores, gonangia, etc., and extends them to all the Diplograptidæ. In the Dendroidea, however, he regards the gonothecæ of Wiman and Holm as corresponding to the nematophores of the Hydrozoa.

As regards the structure of the test, Frech does not adopt Perner's view of the existence of a fourth layer.

Frech lays great stress on the free-swimming or floating character of the Rhabdophora, and explains many of the peculiar structures found in Graptolites by the assumption that they were connected with their swimming mode of life. He recognises four different modifications of swimming organs :

1. The bladder in *Diplograptus physophora* is a "rudder-like propelling organ." The same is the case with the vesicle in *Monograptus pala*, of which he gives a theoretical drawing of colonies attached to a float. 2. The so-called disc at the base of *Climacograptus bicornis* he regards as having served in some way for the movement of the animal. 3. A third modification is found in *Cephalograptus*, where the "whole surface of the hydrothecæ has widened and taken on a rudder-like form." He gives a theoretical drawing of *Petalograptus folium* attached to a float. 4. A fourth modification occurs in *Dicellograptus divaricatus*, in which a membrane exists between the branches.

All these aided in giving the Plankton colony-animals an undulating up-and-down movement rather than a forward one. As it is doubtful whether all the *Monograpti* possessed floats, the "float," therefore, must not be regarded as an organ of systematic importance. In those forms that have a float, "the axis

is the rudder-stem, and the float itself the rudder-fins;" the fixed Dendroidea have no such organ.

Frech does not regard the spine-like appendages to the apertures of the cells, as found in the Glossograptidæ, as of systematic importance, but as protective organs, "perhaps also sensory."

Frech divides the Graptolites into two main groups, differing from each other in the development of the axis, the rudder floats, and common canal, and also in their embryonic stages.

ORDER 1: *Axonophora*.—This includes *Diplograptus*, *Climacograptus*, *Dicranograptus*, *Dicellograptus* and *Monograptus*. The sicula is distal in position, and the later polyps insert themselves between the apex of the sicula and the central bladder. The apertures are directed inwards (proximally), a virgula is present, a common canal absent. The mode of life is planktonic, with a passive or active movement.

ORDER 2: *Axonolipa*.—This includes the Dichograptidæ and the Dendroidea. The sicula is proximal, and the younger cells grow distally, their apertures being directed outwards. A common canal for the cœnosarc exists in the Dichograptidæ, but not in the Dendroidea. "A virgula has not been observed in any of the main types of this order, in spite of numerous microscopic sections."

The Retiolitidi, according to Frech, correspond in the structure and arrangement of the hydrothecæ, and in the presence of an axis, to *Diplograptus;* and *Retiolites* is a "younger derived form" of that genus. As regards the Dendrograptidi, Frech accepts Wiman's opinion that they had no axis, and he considers that there are many points of contact between the Dendrograptidi and the Dichograptidi.

B. *Embryonal Development of Graptolites.*—Frech gives a summary of Ruedemann's and of Wiman's work, and accepts their conclusions. As regards Ruedemann's work, he seems to think that in addition to the primary hydro-rhabdosomes, there should be "secondary hydro-rhabdosomes," arising direct from the proximal part of the virgula, or from the central plate, and having no siculæ, thus producing a colony like that seen in *Retiograptus*, and he tries to account for the paucity of these non-siculate secondary hydro-rhabdosomes.

Frech emphasises strongly his opinion that "an analogy exists between the development of the Axonolipa and the Tabulate Corals," while "the embryonal polyp of *Phyllograptus* has the greatest similarity to the primary calyx of *Pleurodictyum*." He considers that the terms "Hydrozoa" and "Anthozoa," which are founded on living forms, are in no way applicable to their Palæozoic ancestors. He places the Graptolithidæ as the third member of the following series:

(A) 1, Archarocyathinia. (B) 2, Acalephæ; 3, Graptolithidæ; 4, Tabulata; 5, Stromatoporoidea. (C) 6, Pterocorallia. All except the first and last "take

the place of the modern Hydrozoa, and are perhaps phylogenetically related to them."

C. *The Position of the Graptolites in the Zoological System.*—The Axonophora and Axonolipa are very distinct, the only point of similarity between them being the form of the sicula. He discusses at great length the relationship of the Graptolites to the Sertularians, but thinks that all the resemblances are superficial. Between the Dendrograptidi and living Plumularians, however, there is much direct relationship in the organisation of the grown animal, and the only main distinction between them is the want of a common canal in the former, and the shape of the embryonic polyps.

D. *Classification.*—The classification adopted by Frech differs in many respects from that proposed by British and Swedish workers, and the number of genera and species, are, in the majority of cases, materially decreased. His classification is as follows:

ORDER I.—AXONOLIPA.

1. Dendrograptidi.—(Hydrothecæ dimorphous, larger nutritive and smaller protective polyps, branching irregular.)

(a) *Dictyonema.*—Nineteen species are recorded, and *D. flabelliforme* and *D. tuberosum* are re-described.

(b) *Callograptus.*—*C. Salteri* and *C. elegans* are described.

(c) *Dendrograptus.*—Nine species are recognised and several figured.

(d) *Ptilograptus.*—Four species are recognised, and *P. acutus* is described and figured.

(Frech considers that *Thamnograpsus*, *Inocaulis* and *Corynoides* are "incompletely known, and their systematic position uncertain.")

2. Dichograptidi.—(This includes the Dichograptidæ, Leptograptidæ, and the Phyllograptidæ.) Free-swimming hydrothecæ, one kind only, branching dichotomous.

A. *Sub-family* Didymograptini (two main branches):

(a) *Bryograptus.*—*B. Kjerulfi* (= *B. Callavei*), *B. retroflexus*, *B. ramosus*, *B. Hunnebergensis* and *B. sarmentosus.* (He gives a table showing the phylogenetic relationship of the genus.)

(b) *Cœnograptus* s. str.. *C. gracilis* and *C. fragilis*, and including *Trichograptus.*

Pterograptus, sub-gen.—*P. elegans.*

Pleurograptus, sub-gen.—*P. linearis*, *Amphigraptus* (*A. divergens*).

(c) *Didymograptus.*—In the group of *D. Murchisoni* he includes *D. Murchisoni* var. *gemina*, *D. dentatus* (*indentus*), *D. v-fractus*, *D. nitidus*: in the group of *D. flaccidus* (*Leptograptus ex parte*), *D. extensus*, *D. minutus*, *D. flaccidus*; and in the group (or sub-genus) of *D. gibberulus* that species only.

B. *Sub-family* Tetragraptini (four main branches).

(a) *Dichograptus.—D. octobrachiatus* and *D. Logani.*

Temnograptus, sub-gen.—*T. Milesi, T. reticulatus, T. annulatus, T. diffusus, T. expansus, T. Richardsoni*, and a new species, *T.* **Barroisi** (=*Rouvilligraptus Richardsoni*, pars).

Clonograptus, sub-gen.—*C. tenellus, C. flexilis, C. rigidus, C. multifasciatus, C. Thureaui.*

(b) *Tetragraptus.*—In the group of *T. Bigsbyi,—T. Bigsbyi, T. bryonoides, T. denticulatus, T. fruticosus*, and *T. octonarius.* In the group of *T. Headi,—T. Headi, T. alatus, T. quadribrachiatus.*

C. *Sub-family* Phyllograptini (four main branches which grow together dorsally).

Phyllograptus.—P. typus, P. ilicifolius, P. Anna, P. angustifolius, P. Loringi.

Order II: Axonophora.

3. Climacograptidi.—(Hydrothecæ at right angles, outer edge straight, indented by the thecal apertures.) This includes, in addition to *Climacograptus*, the Dicranograptidæ, and the Glossograptidæ.

(a) *Retiograptus.—R. eucharis, R. tentaculatus, R. ? Geinitzianus.*

(b) *Climacograptus.*—The group of *C. bicornis* includes *C. bicornis*, the new species *C.* **Nicholsoni,** and *C. antennarius.* The group of *C. scalaris, C. Scharenbergi, C. typicus, C. estonus mut. Kuckersianus, C. estonus, C. scalaris, C. caudatus, C. internexus, C. Wilsoni* and *C. retioloides.*

(c) *Dicranograptus.—D. ramosus, D. Clingani, D. Nicholsoni.*

Dicellograptus, sub-gen.—*D. anceps, D. complanatus, D. divaricatus, D. Morrisi, D. moffatensis, D. intortus, D. Forchammeri, D. patulosus, D. sextans, D. elegans.*

(d) **Monoclimacis,** n. g.—Rhabdosome with only one row of cells, hydrothecæ like *Climacograptus. M. vomerinus, M. personata, M. crenularis, M. continens, M. spinulosa.*

The genus *Trigonograptus* probably belongs to this group.

4. Diplograptidi.—(Rhabdosome with two rows of cells; hydrothecæ oblique; outer edge toothed.)

(a) *Diplograptus.*—

Group I includes *D. pristis, D. foliaceus, D. teretiusculus, D.* **sertularoides** n.s., *D. physophora, D. bellulus, D. gracilis*, and *D. palmeus.*

Group II (=*Glossograptus*) includes *D. Whitfieldii, D. uplandicus* and *D. cf. aculeatus.*

Glyptograptus, sub-gen.—*D. amplexicaulis, D. tamariscus.*

Orthograptus, sub-gen.—*O. quadrimucronatus.*

Petalograptus, sub-gen.—*P. folium* mut. *ovato-elongata, P. folium*, and *P. ovatus.*

Cephalograptus, sub-gen.—*C. cometa*.

(b) *Dimorphograptus*.—*D. elongatus*, *D. Swanstoni*.

5. Monograptidi.—(Rhabdosome with one row of cells, rarely branched. Hydrothecæ of many kinds.)

(a) Rhabdosome simple :

i. *Monograptus*.—(Hydrothecæ of many forms and bent round in a distal direction, attached to the axis.)

In the group of *M. priodon* he includes *M. priodon* mut. *Clintonensis* var. *Flemingi*, *M. galænsis*, *M. riccartonensis*, *M. cultellus*.

In the group of *M. Becki*,—*M. Becki*, *M. cygneus*, *M. scanicus*, *M. Barrandei*, *M. attenuatus*.

In the group of *M. runcinatus*,—*M. runcinatus*, *M. dextrorsus*, *M. nodifer*.

In the group of *M. turriculatus*,—*M. turriculatus*, *M. proteus*, *M. spiralis*, *M. triangulatus*. In addition he describes *M. resurgens* and *M. Clingani*.

ii. *Pristiograptus*.—(Hydrothecæ, as in *Diplograptus*, neither elongated nor bent round.)

In the group of *P. frequens* he includes *P. frequens*, *P. dubius*, *P. colonus*, *P. Roemeri*, *P. jaculum*, *P. Hisingeri*, *P. leptotheca*, *P. uncinatus*, *P. leintwardinensis*, *P. pala*.

In the group of *P. gregarius*,—*P. gregarius*, *P. cyphus*.

In the group of *P. testis*,—*P. testis*, and *P. discus*.

iii. **Linograptus** n. g.—(Like *Pristiograptus*, but the sicula and hydrothecæ both open distally.) *L. Nilssoni*, *L. concinnus*, *L. Sandersoni*, *L. tenuis*, *L. bohemicus*.

iv. *Rastrites*.—(Hydrothecæ straight, not connected with the axis.)

R. Linnæi, *R. maximus*, *R. fugax* var. *distans*, *R. peregrinus*, *R. hybridus*, *R. gemmatus*, *R. capillaris*, *R. Barrandei*.

(b) Rhabdosome branched :

Cyrtograptus.—*C. Grayiæ*, *C. Murchisoni*, *C. rigidus*, *C. pulchellus*, *C. Linnarssoni*, *C. Carruthersi*.

6. Retiolitidi.—(Rhabdosome with two rows of cells, perisarc consisting of a network of chitinous threads.)

(a) (Hydrothecæ oblique) :

i. *Retiolites*.—*R. Geinitzianus*, *R. venosus*, *R. australis*.

ii. *Stomatograptus*, sub-gen.—*S. grandis*.

iii. *Lasiograptus*.—*L. bimucronatus*, *L. costatus*, *L. margaritatus*.

(b) **Gothograptus**, n. g.—(Hydrothecæ vertical.) *G. nassa*.

The range and distribution of the Graptolites and dealt with in some detail, and a table is given of their geological distribution.

1897. *Elles*, "The Sub-genera *Petalograptus* and *Cephalograptus*," 'Quart. Journ. Geol. Soc.,' vol. liii.

In 1897 Elles published a paper on the "Sub-genera *Petalograptus* and *Cephalograptus*," in which she adduced evidences that these sub-genera are quite distinct, and readily distinguished the one from the other. She worked out carefully the structure of the various species belonging to the sub-genera, especially that of the proximal end, showing that it differs in important particulars in the two groups.

From her study of these species she concludes that the *Petalograpti* have been derived from *Orthograptus foliaceus* through *O. truncatus*, and the *Cephalograpti* direct from the *Petalograpti*, *Cephalograptus petalum* being the intermediate form.

Description of Species.—The following species are re-described in detail and re-figured, *Petalog. folium*, *P. palmeus*, var. *latus*, var. *tenuis*, and var. *ovato-elongatus*, *P. ovatus*, *Cephalog. cometa*, and two new species, *P.* **minor** and *C.* **petalum.**

1897. *Wiman*, "Ueber den Bau einiger Gotländischen Graptoliten," 'Bull. Geol. Inst. Upsala,' vol. iii, art. no. 10.

In this year also Wiman gave a further account of his extended researches on the structure of the Graptolites describing and figuring a large series of cross-sections which he had made of some Graptolites from Wisby in Gothland preserved in silicified limestone.

He figures a good specimen of *Dictyonema cavernosum* provided with stolons, one of *Dictyonema* (?) *tuberosum* and one of *Climacograptus*. Other forms dealt with are isolated specimens of Dendroidea, which, however, he does not attempt to refer to definite species.

1898. *Meek, A.*, "On Graptolites," 'Proc. Univ. Durham Phil. Soc.,' vol. i, pt. 2.

In a paper read before the Durham Philosophical Society A. Meek summarised the researches of Holm and Ruedemann respecting the structure and mode of growth of the Graptolites.

He lays stress on the supposed absence of a virgula in the Dichograptidæ, and suggests that as they "do not seem to have possessed a means of fixing themselves," "it must be supposed that they had the power of movement and temporary attachment with whatever the living contents of the thecæ provided." Forms like *Phyllograptus* he thinks were "purely crawling forms—say by means of tentacles or pseudopodia."

He tentatively suggests that the presence or absence of a virgula might form the basis of a new classification.

1898. *Hall, T. S.*, 'Victorian Graptolites,' part ii, "Graptolites of the Lancefield Beds," 'Proc. Roy. Soc. Victoria,' n.s., vol. xi, pt. 2.

In 1898 T. S. Hall made a further contribution to the graptolitic fauna of the Lancefield Beds, Victoria, which confirmed his original views that they underlie the *Tetragraptus fruticosus* zone.

Description of Species. — He describes and figures a number of new species of Graptolites, including *Bryograptus*

Victoriæ, *Bryog.* **Clarki,** *Leptog.* **antiquus,** *Didymog.* **Pritchardi** (a form occasionally possessing three branches), *D.* **Taylori,** *Tetrag.* **decipiens,** *Dictyonema* **pulchellum,** and he re-describes and figures *Clonog. flexilis, C. magnificus, C. rigidus* var. *tenellus, Phyllograptus* species and *Dictyonema Macgillivrayi.*

According to Hall, *Leptograptus* and *Bryograptus* here occur together on the same slabs, and he explains this unusual association by concluding that in Victoria *Bryograptus* ranges up to the Ordovician.

1898.
Elles,
"The Graptolite Fauna of the Skiddaw Slates," 'Quart. Journ. Geol. Soc.,' vol. liv.

In 1898 Elles published a revision of the Graptolite fauna of the Skiddaw Slates of the Lake District, the forms found in these rocks being re-described, and particular attention being paid to details of structure.

The development of *Bryograptus* is worked out in *B. Kjerulfi, B. cf. Callavei*, and *B. ramosus*; and a new variety, var. **cumbrensis,** is described. The following species are described: *Clonograptus flexilis, C. cf. tenellus, Clonograptus* sp.; *Loganograptus Logani; Trichograptus fragilis; Temnograptus multiplex; Trochograptus diffusus; Schizograptus reticulatus, S.* **tardifurcatus**, sp. nov.; *Pleurograptus vagans; Pterograptus* sp.; *Dichograptus octobrachiatus, D.* **separatus,** sp. nov.; *Tetragraptus quadribrachiatus, T. Headi, T. crucifer, T. Bigsbyi, T. serra,* and two new species, *T.* **pendens** and *T.* **Postlethwaitii;** *Phyllograptus ilicifolius* var. **grandis,** nov., *P. Anna, P. typus, P. angustifolius; Didymograptus gibberulus.* The structure of this last species is worked out in detail, and a somewhat anomalous point of structure is noticed, namely, the apparent presence of a second connecting canal, uniting the second theca of the primary stipe with the first theca of the secondary stipe.

The following species of *Didymograptus* are re-described: *D. nitidus, D. Nicholsoni, D. affinis, D. extensus, D. patulus, D. gracilis, D. fasciculatus, D. v-fractus,* var. *volucer, D. indentus,* var. *nanus, D. bifidus.*

The genus *Azygograptus* is considered by Elles to belong to the Dichograptidæ (comp. Wiman) rather than to the Nemagraptidæ, on account of the structure of the proximal end being similar to that in the Dichograptidæ. *A. Lapworthi, A. cœlebs, A. suecicus,* are re-described, together with *Leptograptus* sp.; *Dicellog. moffatensis; Diplog. dentatus, D. cf. teretiusculus, D. appendiculatus; Climacog. Scharenbergi; Cryptograptus? antennarius, C. Hopkinsoni; Glossograptus fimbriatus, G. cf. Hincksii, G. armatus; Trigonograptus ensiformis, T. lanceolatus; Thamnograptus Doveri.* Some of the above-mentioned species are figured.

The range and distribution of the various species of Graptolites are given; the Skiddaw Slates are divided into zones and compared with similar beds in South Wales and Sweden, the sub-divisions of the Skiddaw Slates agreeing closely with those given by Marr in 1894.

As regards the phylogenetic relationships of the Skiddaw Slates Graptolites, Elles agrees with Marr and Nicholson in the main, namely, that (1) the re-

semblances between species of different genera are of genetic origin, and therefore (2) of systematic value; (3) in any natural group the forms with relatively fewer branches were developed from the more complex forms, and therefore (4) the so-called "genera" are far more of a chronological than of a zoological significance. She considers, however, that the various forms are "most probably the result of development along certain special lines."

According to her, therefore, there is a "Group relationship"; for example, "all the 'tuning forks' *Didymograpti* have been derived from what may be termed the *fruticosus* type of *Tetragraptus*, though not all from *T. fruticosus* itself."

She divides them into two main groups, (1) those derived from *Bryograptus*, (2) those derived from *Clonograptus*.

In the first group there are five sub-groups:

(*a*) Group containing *Bryograptus ramosus* var. *cumbrensis*, *Tetrag. pendens*, and *Didymog. indentus*.

(*b*) Group containing *Bryograptus ramosus* var. *cumbrensis*, *Tetrag. fruticosus*, and *Didymog. furcillatus*.

(*c*) Group containing *Bryograptus ramosus* var. *cumbrensis*, *Tetrag. Postlethwaitii*, and *Didymog. bifidus*.

(*d*) Group containing forms derived from *Tetragraptus Bigsbyi*.

(*e*) Group containing forms derived from *Bryograptus Callavei*.

In the second group there are three sub-groups:

(*a*) Group containing *Dichograptus octonarius*, *Tetrag. serra*, and *Didymograptus arcuatus*.

(*b*) Group containing *Loganograptus Logani*, *Didymograptus octobrachiatus*, *D. extensus*, and *Tetragraptus quadribrachiatus*.

(*c*) Group containing *Tetragraptus Headi* and *Didymograptus patulus*.

Elles does not regard the angle of divergence of the branches as of phylogenetic importance; the mode of development has been simply in the direction of "failure in dichotomous division."

1899.
Perner,
"Études sur les Graptolites de Boheme,"
Prague, part iii,
sect. *b*.

In 1898 Perner published the second section of the third part of his monograph on the Graptolites of Bohemia, completing the descriptive part of his work. It is devoted to a description of the Graptolites of the upper part of Stage E.

Description of Species.—In the group of the Opisopodes of the genus *Monograptus*, he describes and figures the well-known forms: *Monog. priodon*, *M. riccartonensis*, *M. latus*, *M. sartorius*, and *M. vesiculosus*, and the new species and varieties *M. priodon* var. **rimatus**, var. **validus**, *M.* **Jaekeli**, *M.* **unguiferus**, and *M.* **Suessi.**

In the group Leptopodes Perner re-describes *M. Nilssoni* of Barrande and

clears up the previous confusion as to the exact identity of this species, showing that Barrande had originally included three different species under this name.

The group Prosopodes includes *Monog. Roemeri*, *M. dubius*, *M. colonus*, *M. chimæra*, *M. testis*, *M. bohemicus*, and the following new species: *M.* **Kayseri**, *M.* **hercynius**, *M.* **gotlandicus**, *M.* **subcolonus**, *M.* **largus**, *M.* **transgrediens**, *M.* **vicinus**, *M.* **ultimus**, *M.* **clavulus**, *M.* **Fritschi**, *M.* **bohemicus** var. **rarus**.

The group Helicopodes includes only *Monog. spiralis* var. *subconicus*.

The group Orthopodes contains *M. crenulatus* and *M. vomerinus*.

The genus *Cyrtograptus* is represented by *Cyrtog. flaccidus*, *C. Lundgreni*, *C. Murchisoni*, *C. Carruthersi*, and the new species *C.* **tubuliferus**.

Under the genus *Retiolites* Perner describes *Retiolites Geinitzianus*, *R.* (*Gothograptus*) *nassa*, and *Stomatograptus grandis*.

1899.
Peach and Horne,
"The Silurian Rocks of Britain," vol. i, Scotland.

A memoir of very great importance as regards its bearing on the range and zonal value of the Graptolites was published in 1899. This was H. M. Geological Survey Memoir on the "Silurian Rocks of Scotland." The officers of the Survey confirm Lapworth's conclusions respecting the zonal distribution of Graptolites in the rocks of the Southern Uplands, and employing these fossils as zone indices, they work out and illustrate in detail the geology of the districts in which they occur in the course of their description of the entire Upland Sequence.

1899.
Törnquist,
"The Monograptidæ of the Scanian *Rastrites* Beds," 'Acta Univ. Lund.,' vol. xxxv.

In 1899 Törnquist published the second part of his Monograph on the "Graptolites of the Scanian *Rastrites* Beds." This is devoted to the study of the Monograptidæ.

Törnquist employs throughout the terminology adopted by him in the first part of this work.

The following synopsis is given of the species of Monograptidæ described, the grouping being based mainly on the form of the polypary and the character of the sicula and thecæ.

A. All the thecæ of the same type; each wholly adnate to the proximal wall of the theca next succeeding.

(*a*) Sicula attaining a length of more than 4 mm; rhabdosome curved. *M. gregarius* and *M.* **acinaces**.

(*b*) Sicula not exceeding 2 mm. in length; rhabdosome stout, straight. *M. leptotheca*, *M. jaculum*, *M. nudus*, *M.* **regularis**, n. s.

(*c*) Sicula not exceeding 2 mm. in length; rhabdosome stout, proximally incurved. *M.* **inopinus**, n. s.

(*d*) Sicula not exceeding 2 mm. in length; rhabdosome arcuate, gradually widening from the proximal extremity. *M. tenuis*.

(*e*) Sicula not exceeding 2 mm. in length; rhabdosome slender, distally straight, or irregularly bent. *M.* **incommodus,** n. s.

B. Thecæ dimorphous: the distal ones of the same type as that characteristic of the preceding section, each of the proximal thecæ wholly, or at least distally, free from the succeeding theca.

(*a*) Rhabdosome gradually widening. *M. revolutus* var. **austerus,** nov., *M.* **difformis,** n. s., *M. cf. cyphus.*

(*b*) Rhabdosome abruptly acquiring its normal width. *M. limatulus.*

C. All the thecæ of the same type; each being wholly, or at least distally, free from the theca next in advance.

(*a*) Rhabdosome stout and straight, or only having the sicular portion bent backward. *M. runcinatus, M. priodon, M. Sedgwickii, M.* **harpago,** n. s.

(*b*) Rhabdosome slender, proximally arcuate, but not enrolled, distally straight or irregularly bent. *M.* **elongatus,** n. s.

(*c*) Proximal portion of the rhabdosome forming a more or less complete flat or sub-conical spiral, or at least showing a tendency to form such a figure; prolific side convex. *M.* **denticulatus,** n. s., *M. fimbriatus, M. triangulatus, M.* **nobilis,** n. s., *M.* **decipiens,** n. s., *M. convolutus, M. subconicus.*

(*d*) Rhabdosome coiled up in an elongated conical helix bearing thecæ on the convex margin. *M. turriculatus.*

(*e*) Rhabdosome enrolled in a conical spiral-bearing theca on the concave margin. *M. proteus.*

(*f*) Rhabdosome forming a narrow flat spiral, bearing thecæ on the concave margin. *M. discus.*

(*g*) Rhabdosome fish-hook-shaped; prolific side concave. *M. exiguus.*

Törnquist points out that he does not imagine that the above arrangement is "in every respect a natural one, though he is of opinion that several of the sub-divisions may be found to coincide with true natural groups."

1899.
Törnquist,
"Några anteckningar om Vestergötlands öfversiluriska Graptolitskiffrar," 'Geol. Fören. Förh.,' bd. 21.

In a short stratigraphical paper published the same year, Törnquist noticed the various localities where the Upper Silurian Graptolitic zones are recognisable in Vestrogothland.

1899.
Hall, T. S.,
"The Graptolite-bearing Rocks of Victoria, Australia," 'Geol. Mag.,' dec. 4, vol. vi, no. x.

In 1899 Hall published a general account of the Graptolite-bearing beds of Victoria, and their divisions, comparing them with those of Europe.

Hall describes and figures three new species of Graptolites, namely *Tetragraptus* **projectus,** *Goniograptus* **macer** and *Trigonograptus* **Wilkinsoni,** and a species of *Monograptus* which he does not name; he re-describes *Didymog. gracilis* and *Dichog. octonarius*, and re-figures *Bryograptus Victoriæ*, and *Leptograptus antiquus*.

He recognises four main divisions in the Lower Ordovician of Victoria: (1) Lancefield Series, (2) Bendigo Series, (3) Castlemaine Series, and (4) Darriwill Series. The Graptolites characteristic of each group are fully given. The Upper Ordovician is represented in a few localities, but the Silurian contains only one or two species of Graptolites.

A special point dwelt upon in this paper is the apparent want of harmony between the Graptolite zones of Australia and of Europe. Thus, in addition to the occurrence of *Bryograptus* and *Leptograptus* in association, Hall considers that *Loganograptus* appears very high up in the series, and never in association with *Phyllograptus typus*, while *Didymog. bifidus*, which is characteristic of an Upper Arenig Fauna in Europe, here disappears before *Phyllograptus typus*.

1900.
Elles,
"The Zonal Classification of the Wenlock Shales of the Welsh Borderland," 'Quart. Journ. Geol. Soc.,' vol. lvi.

In 1900 Elles published a paper on the "Zones of the Wenlock Shales," demonstrating the systematic chronological arrangement of the various species of Graptolites in the Wenlock Rocks of Britain. A few new species were described, and many already well-known forms, all with special regard to the structure of the proximal end.

Under the species *Monograptus Flemingii* Elles recognises four varieties, α, β, γ, and δ, which are valuable zonally, as they are practically confined to certain definite horizons. The same is the case with *M. vomerinus*, of which she recognises three varieties; *M.* **flexilis,** *M.* **irfonensis,** and *M. testis* var. **inornatus,** are new forms. A new species of *Cyrtograptus*, *C.* **symmetricus,** is also described.

The Wenlock Shales are worked out in (1) the Builth district, (2) the Long Mountain, and (3) the Dee Valley. Elles finds that in the Builth district they are capable of division into six zones characterised by species of *Cyrtograptus*, and that the majority of these Wenlock zones are also to be found in the other areas. The evidences adduced in this paper prove for the first time in Britain, that the Wenlock Shales are as capable of Graptolitic zonal division as are the Birkhill Shales, and that these British Wenlock zones run parallel to the Wenlock zones already suggested by Tullberg for Scandinavia.

1900.
Wood,
"The Lower Ludlow Formation, and its Graptolite Fauna," 'Quart. Journ. Geol. Soc.,' vol. lvi.

In the same year Wood worked out the Graptolitic fauna of the Lower Ludlow Shales, and proved that these were equally capable of division into Graptolite zones.

Range and Distribution.—In this paper the distribution of the Ludlow Graptolites is first worked out in the typical Ludlow District, and four zones are recognised. Similar zones

are afterwards shown (with the addition of a fifth zone) to hold in the main in the Builth District and Long Mountain area of the Welsh Borderland. Brief notes are also given of the Ludlow graptolitic fauna in the Dee Valley, the Lake District, South Scotland, Dudley, and the Abberley Hills.

Description of Species.—The following species, which had been already named by previous observers, are re-described and re-figured:

Group I.—*M. dubius, M. tumescens* var. *minor, M. gotlandicus, M. ultimus.*

Group II.—*M. colonus* var. *ludensis, M. Roemeri.*

Group III.—*M. chimæra* var. *Salweyi, M. leintwardinensis.*

Group IV.—*M. uncinatus* var. *micropoma.*

Group V.—*M. scanicus.*

Group VI.—*Gothograptus nassa, M. Nilssoni, M. bohemicus.*

The following new species are figured and described: *M.* **vulgaris,** var. **a,** var. **b,** *M.* **tumescens,** *M.* **comis,** *M. colonus* var. **compactus,** *M.* **varians,** var. **a,** var. **b,** var. **pumilus,** *M. chimæra* var. **a,** *M. leintwardinensis* var. **incipiens,** *M. uncinatus* var. **orbatus,** *M.* **crinitus,** *Retiolites* **spinosus.**

1900.
Lapworth, H.,
"The Silurian Sequence of Rhayader," 'Quart. Journ. Geol. Soc.,' vol. lvi.

A third paper of especial stratigraphical importance was published during this year by H. Lapworth on the "Silurian Sequence of Rhayader."

He shows that in the district of Rhayader there occur representatives of all the Llandovery-Birkhill Graptolitic zones as well as of the Tarannon; these zones are mapped by him in detail.

He describes and figures three new species: *Climacograptus* **parvulus,** *C.* **extremus,** and *Diplograptus* **magnus,** and gives a description of *Diplog. modestus,* which had previously been figured only.

1900.
Hall, T. S.,
"On a Collection of Graptolites from Mandurama," 'Records Geol. Survey, N. S. Wales,' vol. vii, pt. 1.

In the year 1900 Hall published the results of his examination of a collection of Graptolites made by Mr. E. F. Pittman from Mandurama.

Hall describes and figures three forms which he considers are new, but only names two, namely, *Climacograptus* **affinis** and *Diplograptus* **manduramæ.**

1901.
Newton,
"Note on Graptolites from Peru," 'Geol. Mag.,' dec. 4, vol. viii, no. v.

In 1901 Newton described and figured a slab of Graptolites collected by Mr. Jessop from the province of Carabaya, Peru. The species to which these belong is uncertain, but they closely resemble *Diplograptus truncatus,* Lapw. They are "indicative of beds near the uppermost part of the Lower Silurian."

In the year 1901 Törnquist published the results of his researches on the *Phyllo-Tetragraptus* beds of Scania and Vestrogothland, and recognised

1901. *Törnquist*, "Graptolites of the Lower Zones of the Scanian and Vestrogothian *Phyllo-Tetragraptus* Beds," 'Acta Univ. Lund.,' vol. xxxvii, pt. 2, no. 5.

in these beds for the first time the existence of five distinct zones:

(*a*) Zone of *Tetragraptus phyllograptoides*.
(*b*) Zone of *Didymograptus balticus*.
(*c*) Zone of *Phyllograptus densus*.
(*d*) Zone of *Isograptus gibberulus*.
(*e*) Zone of *Phyllograptus cf. typus*.

The Orthoceras Limestone intervenes between the last two zones, and therefore the contrast between the faunas of these zones appears to be greater than between the others.

Before proceeding to the description of species, Törnquist suggests and explains certain terms which he employs throughout this paper.

The branch which "issues on the same side of the sicula as the first theca," he calls the "primordial stipe," the other he names the "complemental stipe."

He also distinguishes between the various parts of the first theca, and designates them: (1) The "initial portion," (2) "ramifying portion," and (3) "apertural portion," or true theca.

Törnquist again points out that there has been considerable confusion in the employment of the term "connecting canal," and that it can no longer be applied to "that part of the complemental stipe which crosses the sicula" in *Didymograptus*, etc., and he suggests the new name of "crossing canal."

In his figures he adheres to the old method of drawing them with the apex of the sicula directed downwards, though he "by no means under-rates the motives which may have prevailed upon some authors to figure these fossils in a different position."

Törnquist recognises the two genera established by Moberg as *Isograptus* and *Mæandrograptus*, though he is undecided whether to regard them as sub-genera of *Didymograptus* or as distinct genera.

Under the genus *Didymograptus*, *sensu latiori*, he describes and figures: *Didymog. suecicus*, *D. patulus* (=*D. hirundo*), *D. extensus*, *D. constrictus*, *D. balticus*, *D. vacillans*, *D. filiformis*, *D.* **flagellifer,** Tullb. MS., and the new species *D.* **undulatus,** *D.* **demissus,** *D.* **geometricus,** *D.* **Holmi,** *D.* **prænuntius,** *D.* **validus,** *D.* **Kurcki,** and *D.* **Mobergi.**

The genus *Isograptus* includes the one species *I. gibberulus*, and Törnquist adds a few additional notes on the structure of the initial end.

The genus *Mæandrograptus* also comprises only one species: *M. Schmalenseei*; the structure of this peculiar form is well brought out by the illustrations.

1901. *Moberg*, "*Pterograptus scanicus*, n. sp.," 'Geol. Fören. Förh.,' bd. 23.

In 1901 Moberg described and figured a new species of *Pterograptus* under the name of *P.* **scanicus,** and he compares it with Holm's species *P. elegans*. This species occurs at Fågelsang associated with a *Climacograptus* and *Didymograptus geminus*.

Sub-genus **Petalograptus,** *Suess.*

1851. *Petalolithus,* Suess, Ueber Böhmische Graptolithen, p. 20.
1873. *Petalograptus,* Lapworth, Geol. Mag., vol. x, p. 500.

The sub-genus *Petalograptus,* as here accepted, includes all those *Diplograpti* in which the polypary was more or less tabular in transverse section, and the thecæ were rounded tubes approximating in form and appearance to those of *Phyllograptus.* Within these limits, the outline of the polypary varies from foliiform (*Petalog. folium*) to wedge-shaped (*Cephalog. cometa*).

It is found convenient to refer to the special group or section constituted by the more wedge-like forms under Hopkinson's title of *Cephalograptus,* and to the collective group constituted by all the other forms of the sub-genus under the title of *Petalograptus* proper.

The appearances presented by the thecæ in this sub-genus naturally vary with the general outline of the tabular polyparies. In the more leaf-like forms belonging to *Petalograptus* proper, the axis of the theca is curved and directed outward, so that the apertural edge, though straight and normal, appears concave and lies obliquely with respect to the general ventral margin of the polypary. In the more wedge-like forms grouped under *Cephalograptus* the axis of the theca is straight and directed upward, so that the flattened-out apertural edge is straight and practically horizontal.

The mode of development of the initial parts of the polypary is the same as that characteristic of the Diplograptidæ in general. But in the group *Cephalograptus* we find a special modification, which consists in the postponement of the growth of th. 1^2 from th. 1^1 until after the latter has grown up to, or beyond, the apex of the sicula, and the sicula itself is thus left entirely free on one side, in the unprotected manner of that in the families of the Dimorphograptidæ and the Monograptidæ. The *Cephalograpti* are, however, none the less clearly true Diplograptidæ; for their polypary is biserial throughout, whereas in the Dimorphograptidæ the polypary is uniserial in its earlier portion and biserial in its later portion, and in the Monograptidæ the polypary is uniserial from its commencement.

Group I. *Petalograptus* (proper).

Petalograpti in which the polypary is foliiform; proximal end somewhat protracted, never rounded. Sicula embedded, completely visible only in the obverse aspect of the polypary. Septum complete or partial. Thecæ of various lengths, axis curved, apertural margins concave and oblique in compressed examples.

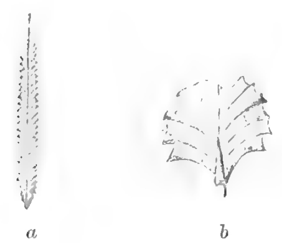
Petalograptus palmeus s.s. (Barrande). Plate XXXII, figs. 1 *a—d*.

1850. *Graptolithus palmeus*, Barrande, Grapt. de Bohême, p. 59, pl. iii, figs. 1—7.
1851. *Petalolithus palmeus* and *parallelo-costatus*, Suess, Ueber Böhmische Graptolithen, pp. 20, 21, pl. viii, figs. 1, 2, 4.
1852. *Diplograptus palmeus*, Geinitz, Die Graptolithen, p. 21, pl. i, figs. 5—19.
1853. *Diplograptus palmeus*, Richter, Zeitsch. d. deutsch. geol. Gesellsch., vol. v, p. 455, pl. xii, figs. 8—10.
1876-1880. *Diplograptus palmeus*, Zittel, Traité de Paleont., vol. i, p. 305, fig. 214 *d*, *e*.
1880-1881. *Diplograptus palmeus*, Linnarsson, Geol. Fören. Förhandl., vol. v, p. 522, pl. xxiii, figs. 26—28.
1887. *Diplograptus palmeus*, Törnquist, Geol. Fören. Förhandl., vol. ix, pp. 478—481.
1890. *Diplograptus palmeus*, Geinitz, Graptoliten des k. mineralog. Mus. Dresden, p. 26, pl. A, figs. 39, 41—43.
1893. *Diplograptus palmeus*, Törnquist, Structure of Some Diprionidæ, Acta Univ. Lund., vol. xxix, p. 9, figs. 29—35.
1897. *Petalograptus palmeus* s.s., Elles, Quart. Journ. Geol. Soc., vol. liii, p. 193, pl. xiv, figs. 1—4.
1897. *Diplograptus palmeus*, Törnquist, Diplog. and Heteroprionidæ of Scanian *Rastrites* Beds, Acta Reg. Soc. Physiog. Lund., vol. viii, p. 10, pl. i, figs. 25, 26.

Polypary from 1—3 cm. in length, widening at once to a breadth of 2·5—3 mm., and this being maintained the polypary has sub-parallel sides, but is rounded off distally. Thecæ twelve to fourteen in 10 mm., alternate, with an average length of 2 mm., three times as long as wide, overlapping two thirds of their length; apertural margins concave, oblique.

Description.—The sicula has usually a length of about 2 mm., and extends up to the base of th. 3^2; it is therefore longer relatively to the thecæ than that of *Petalog. folium.* In the Gala-Tarannon examples the virgella seems to have been particularly stout and strong, but in the examples occurring at lower horizons this spine is either wanting altogether, or is only represented by a short fragment.

FIGS. 188 *a* and *b*.—*Petalograptus palmeus* (Barr).



a. Complete specimen, reverse aspect, but showing sicula. Nat. size. Zelkovice, Bohemia. Figured, Elles, Quart. Journ. Geol. Soc., liii, pl. xiv, fig. 1. Coll. Brit. Museum (Nat. Hist.).
b. Reverse aspect of young specimen, showing sicula pressed through. Dobb's Linn, Birkhill Shales. Coll. Geol. Survey of Scotland, Edinburgh.

Th. 1^1 originates close to the aperture of the sicula, and grows outward and upward at once, and its axial line makes a very decided curve; th. 1^2 grows in a manner very similar to that of *Petalog. folium* except that its curvature is greater and is developed earlier than in that species, so that the sicula is not free for so large a fraction of its length on the right side. In the obverse aspect of the polypary the sicula is apparently free for about one quarter of its length on the right side, but in the reverse aspect the aperture is seen to the left only, the remainder being concealed

by the growth of th. 1^2 and the subsequent thecal bases. Th. 1^2 here runs along the side of the sicula for a short distance before curving outward.

The first two thecæ have each a length of rather less than 2 mm., and are equally curved, so that the proximal end of the polypary has a symmetrical appearance and is characteristically short and blunt. The thecæ developed subsequently are rather less curved. The angle of inclination of the thecæ is approximately constant in the narrower forms at 35°, but in the wider polyparies the angle becomes less towards the distal end, though it is never lower than 20°. A complete septum is apparently present.

The virgula is very conspicuous as a general rule; it is usually prolonged distally, and the virgular tube has often the appearance of a vesicle.

Affinities.—*P. palmeus* has often been confused with *Petalog. folium*, but it may be readily distinguished by:—(1) the relative length and width of the polypary as a whole; (2) the short and abruptly terminated character of the proximal end; (3) the length of the sicula relatively to that of the thecæ; (4) the relative length and breadth of the thecæ themselves.

Remarks.—In the classification of the Diplograptidæ (p. 221) we followed the plan usually adopted by previous authors (Lapw. 1873), and regarded *Petalog. folium* as the type of the sub-genus. But in reality *Petalog. palmeus* was the form to which Suess first applied the title *Petalolithus*, and must therefore be taken as the type.

Horizon and Localities.—Birkhill-Gala (zone of *Monog. gregarius* to zone of *M. turriculatus*).

S. Scotland: Dobb's Linn; Belcraig Burn; Garple Linn; Sundhope-on-Yarrow, etc. *Lake District:* Skelgill; Browgill; Pull Beck; Kentmere; Ashgill; Mealy Gill. *Wales:* Conway; Llanystwmdwy, near Criccieth. *Ireland:* Coalpit Bay, Donaghadee.

Associates, etc.—*P. palmeus* is of common occurrence in all the zones between that of *M. gregarius* and that of *M. turriculatus* inclusive. The species with which it is most commonly associated are *Monog. gregarius*, *M. fimbriatus*, *M. triangulatus*, *M. Sedgwicki*, *Glyptog. serratus*, *G. tamariscus*, and *Climacog. Hughesi* in the Birkhill Shales, and *Monog. Becki* and *M. turriculatus* in the Gala-Tarannon beds.

Collections.—British Museum (Natural History), Sedgwick Museum, Lapworth, Fearnsides, and the Authors, etc.

Var. **latus**, Barrande. Plate XXXII, figs. 2 *a—f*.

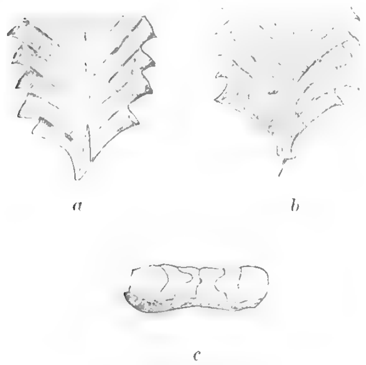
1850. *Graptolithus palmeus* var. *latus*, Barrande, Grapt. de Bohême, p. 61, pl. iii, figs. 3—6.

1897. *Petalograptus palmeus* var. *latus*, Elles, Quart. Journ. Geol. Soc., vol. liii, p. 195, pl. xiv, figs. 5—8.

In addition to the typical form, *P. palmeus*, there occurs in the Middle Birkhill Shales a variety which differs in (1) its greater width; (2) the greater number of thecæ in the same unit of length; (3) the steeper inclination of the thecæ and their greater curvature.

The polypary is commonly shorter than in *Petalog. palmeus* s.s.; it is usually about 1·3 cm. in length. The maximum width of 4—5 mm. is attained at once and maintained to the distal extremity, which is broadly truncate, but occasionally rounded.

FIGS. 189 *a—c*.—*Petalograptus palmeus*, var. *latus*, Barr.



a. Obverse aspect, showing sicula. Long Linn, Dobb's Linn; Birkhill Shales (zone of *M. gregarius*). Coll. Elles.
b. Reverse aspect, showing virgella. Ibid.
c. Transverse section, showing septum, etc. Skelgill, Skelgill Shales. Figured, Elles, Quart. Journ. Geol. Soc., liii, pl. xiv, fig. 14 (as var. *ovato-elongatus*).

The thecæ earliest developed are more curved than those of the typical form and are rather longer; the other thecæ have an average length of fully 2 mm., and are three times as long as wide. The thecæ in general average fourteen to sixteen in 10 mm. At the proximal end they are inclined at 45°, but in the more mature parts of the polypary curve very distinctly in an outward direction, and the angle of inclination decreases uniformly from the proximal up to the distal end, where it is about 20°.

Horizon and Localities.—Birkhill Shales (Middle). *S. Scotland:* Dobb's Linn; Garple Linn; and wherever the zone of *Monog. gregarius* is typically developed. *Lake District:* Skelgill. *Ireland:* Coalpit Bay, Donaghadee; Mullaghnabuoyah, Pomeroy. *Wales:* Pary's Mountain, Anglesea.

Associates, etc.—Var. *latus* occurs in abundance in certain beds of the Birkhill Shales; it makes its first appearance about the middle of the zone of *Monog. gregarius* and is most abundant throughout the middle and upper parts of that zone. It never ranges up into the Gala Series, so far as we are aware. It is commonly associated with *Monog. gregarius*, *M. convolutus*, *M. fimbriatus*, *Glyptog. tamariscus*, etc.

Collections.—British Museum (Natural History), Sedgwick Museum, Lapworth, and the Authors.

Var. **tenuis**, Barrande. Plate XXXII, figs. 3 *a—d*.

1850. *Graptolithus palmeus* var. *tenuis*, Barrande, Grapt. de Bohême, p. 61, pl. iii, figs. 1 and 2.
1897. *Petalograptus palmeus* var. *tenuis*, Elles, Quart. Journ. Geol. Soc., vol. liii, p. 196, pl. xiv, figs. 9, 10.

In addition to the wide variety of *Petalog. palmeus* last mentioned, there is a second variety which differs from the typical form—(1) in its extreme narrowness;

(2) in the smaller number of thecæ in the same unit of length; (3) in the relative proportions of the thecæ and in the general absence of curvature of their walls.

The polypary is usually small, but may be as much as 1·3 cm. in length; it has an average uniform breadth of 1·5 mm. The thecæ number twelve in 10 mm., and are relatively shorter than in other forms. They are about 1 mm. in length, twice as long as broad, and overlap one half their length. The earlier thecæ have slightly curved walls, but those subsequently developed are practically straight. The angle of inclination is uniformly about 35°, and the apertural margins are concave and oblique.

Fig. 190.—*Petalograptus palmeus,* var. *tenuis,* Barr.

Complete specimen, showing sicula and well-marked growth-lines, obverse aspect. Enlargement of Pl. XXXII, fig. 3 *c.*

A septum is present, but apparently is only partial. The virgula may be distally prolonged. The sicula is somewhat smaller than in the typical form.

Horizon and Localities.—Upper Birkhill and Lower Gala.

S. Scotland: Dobb's Linn; Belcraig Burn. *Lake District:* Skelgill; Pull Beck. *Wales:* Conway; Llanystwmdwy, near Criccieth; R. Twymyn, Llanbrynmair; Tarannon River, etc.

Associates, etc.—Var. *tenuis* has much the same range as the typical form; it extends from the top of the zone of *Monog. gregarius* to that of the zone of *M. turriculatus* at the base of the Gala beds. It is never a very common fossil. In general it is found associated with *Monog. convolutus* and *M. gregarius*, in the Birkhill Shales; and with *M. turriculatus*, *M. exiguus*, *M. runcinatus* and *M. pandus* in the Gala-Tarannon beds.

Collections.—Sedgwick Museum, Marr, Lapworth, and the Authors.

Var. **ovato-elongatus**, Kurck. Plate XXXII, figs. 4 *a—d.*

1850. *Graptolithus palmeus*, Barrande, Grapt. de Bohême, pl. iii, fig. 7.

1851. *Petalolithus palmeus*, Suess, Ueber Böhmische Graptolithen, pl. viii, fig. 1.

1868. *Diplograptus palmeus*, Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 523, and pl. xix, figs. 2, 3.

1876. *Diplograptus palmeus*, Lapworth, Cat. West. Scott. Foss., pl. i, fig. 27.

1881. *Cephalograptus ovato-elongatus*, Kurck, Några Nya Graptolitarter från Skåne, Geol. Fören. Förhandl., vol. vi, p. 303, pl. xiv, fig. 10.

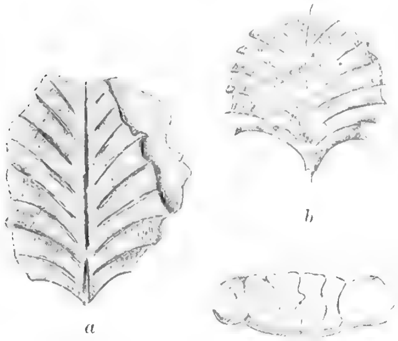
1890. *Diplograptus ovato-elongatus*, Geinitz, Graptoliten des k. mineralog. Mus. Dresden, pl. A, fig. 40.

1897. *Petalograptus palmeus* var. *ovato-elongatus*, Elles, Quart. Journ. Geol. Soc., vol. liii, p. 197, pl. xiv, figs. 11–14.

A third variety, var. *ovato-elongatus*, may in its mature form be very readily

recognised by its characteristic ovato-elongate shape. When young it is practically impossible to distinguish it from *P. palmeus* var. *latus.*

Figs. 191 *a—c.*—*Petalograptus palmeus,* var. *ovato-elongatus,* Kurck.



a *b* *c*

a. Obverse aspect, in relief, showing sicula. Skelgill, Skelgill Shales. Figured, Elles, Quart. Journ. Geol. Soc., liii, pl. xiv, fig. 12. Coll. Elles.
b. Young complete specimen (probably referable to this variety), showing almost circular form; reverse aspect.
c. Transverse section, showing septum and virgula, etc. Skelgill, Skelgill Shales. Figured, Elles, Quart. Journ. Geol. Soc., liii, pl. xiv, fig. 8 (as var. *latus*). Coll. Elles.

It varies from 1—2·5 cm. in length; and also within certain limits in the relative extent of the "*ovate*" and the "*elongate*" parts. The maximum width of 4—5 mm. is reached practically at once, and may be maintained for a well-marked distance if the *ovate* part is long. A diminution in width always takes place, sometimes gradually, at others somewhat abruptly, and this decreased width is then maintained to the distal extremity of the polypary; the part thus diminished in breadth constitutes the *elongate* portion of the polypary.

In the *ovate* part the thecæ have a length of 2·5 mm., and are about four times as long as wide, but their dimensions are less than this in the *elongate* part. The thecæ are widest at their apertures. In the *ovate* part they are inclined at 45°, but the angle diminishes to 20° in the *elongate* part.

The septum does not seem to be complete till four pairs of thecæ have been developed.

Horizon and Localities.—Birkhill-Gala.

S. Scotland: Dobb's Linn; Garple Linn, etc. *Lake District:* Skelgill, Mealy Gill. *Wales:* Conway.

Associates, etc.—Var. *ovato-elongatus* is a fairly abundant fossil in the upper part of the Birkhill Shales. It appears early in the zone of *Monog. gregarius*, and survives into the Lower Gala. It is commonly associated with the typical form, var. *latus*, *Monog. gregarius*, *M. convolutus*, and *Glyptog. tamariscus.*

Collections.—Geological Survey of England and Wales, Sedgwick Museum, Marr, Lapworth, and the Authors.

Petalograptus cfr. **ovatus** (Barr.). Plate XXXII, fig. 6.

1850. *Graptolithus ovatus*, Barrande, Grapt. de Bohême, i, p. 63, pl. iii, figs. 8, 9.
1851. *Petalolithus ovatus*, Suess, Ueber Böhmische Graptolithen, p. 21, pl. viii, fig. 3.
1852. *Diplograpsus ovatus*, Geinitz, Die Graptolithen, p. 20, pl. i, figs. 3 and 4.
1890. *Diplograptus ovatus*, Geinitz, Graptolithen des k. mineralog. Mus. Dresden, p. 25, pl. A, fig. 37.
1897. *Petalograptus ovatus*, Elles, Quart. Journ. Geol. Soc., vol. liii, p. 199, pl. xiv, figs. 15, 16.

Polypary very small, ovate, nearly as wide as long. Sicula large. Thecæ at rate of twenty-eight in 10 mm., very long and narrow, with slight curva-

ture, in contact for nearly the whole of their length; apertural margin slightly concave, everted in compressed specimens.

Description.—The well-known Bohemian species—*Petalog. ovatus*—is but doubtfully represented in the British Isles. The specimen here figured (Pl. XXXII, fig. 6) and provisionally referred to this form comes from Skelgill in the Lake district. It possesses the almost circular outline so characteristic of the Bohemian species, but differs in the character of the proximal end, the earlier thecæ being longer, more curved and less horizontal than is usual.

FIG. 192.—*Petalograptus ovatus* (Barr.).

Typical specimen of *P. ovatus*, natural size. Zelkovice, Bohemia. Coll. Sedgwick Museum.

The sicula is relatively long, measuring 1·5 mm. in length and reaching to the level of the third thecal pair.

The thecæ are very closely set, in the proportion of twenty-eight in 10 mm., but there are generally only seven or eight in the entire length of the polypary.

We figure here for comparison a typical specimen from Zelkovice, Bohemia.

Affinities.—*Petalog. ovatus* is readily separable from all other *Petalograpti* by its nearly circular form, the closely-set thecæ, and their horizontal direction of growth.

Horizon and Localities.—Gala-Tarannon Shales.

Lake District: Skelgill. *N. Wales:* Conway.

Associates, etc.—Very few specimens of *Petalog.* cfr. *ovatus* are known from Britain; the best specimen comes from the Browgill beds of Skelgill, and was found by Mr. W. A. Brend associated with *Monog. Marri.* It is now in the Sedgwick Museum.

Collections.—Sedgwick Museum, and the Authors.

Petalograptus minor, Elles. Plate XXXII, figs. 5 *a*—*e*.

1893. *Diplograptus palmeus,* Törnquist, Structure of some Diprionidæ, Acta Univ. Lund., vol. xxix, pl. i, figs. 29—31.

1897. *Petalograptus minor,* Elles, Quart. Journ. Geol. Soc., vol. liii, p. 201, pl. xiv, figs. 17—21.

Polypary always small, rarely exceeding 1 cm. in length, concavo-convex in section, the convexity being on the reverse aspect; generally oblong in outline, with narrow rounded distal end; widening gradually from origin, and attaining maximum width of about 3 mm. at a point midway between the proximal and distal extremities. Thecæ twelve in 10 mm., alternate, having an average length of 2 mm., four and a half times as long as wide; inclined at 45°; apertural margins slightly concave in profile view.

Description.—The shape of the outline of the flattened polypary, and its

transverse concavo-convexity in specimens preserved in relief, are both very characteristic. In general there is a diminution in breadth of outline as soon as the polypary has attained its maximum width, but this is not invariably the case. Occasionally, as a result of the extreme convexity of the reverse aspect, the distal end in that view has a pointed appearance, but this is unusual.

FIGS. 193 *a* and *b*.—*Petalograptus minor*, Elles.

a *b*

a. Obverse aspect, showing apertural part of sicula. Long Linn, Dobb's Linn; Birkhill Shales (zone of *M. gregarius*). Coll. Elles.
b. Reverse aspect, showing apical part of sicula. Ibid.

The sicula is slender and very long, being usually 3 mm. in length; its apex usually lies on a level with the aperture of th. 4^1, but it tapers so finely in an upward direction that in many specimens it is hard to determine where the sicula ends and the virgula begins. A virgella may often be detected. The sicula is completely visible only when viewed in the obverse aspect, and is free for one third of its length on the right side. Th. 1^1 originates close to the aperture of the sicula, and grows at first in a direction parallel to the sicula itself, but subsequently describes a further concave outward curve; it is usually about 2 mm. in length; in the reverse aspect only its base and a small portion of the side are visible, the rest is concealed by the initial growth of th. 1^2, for in its earliest stage th. 1^2 closely follows the direction of growth of the sicula. When the polypary is shown in the obverse aspect th. 1^2 appears to originate one third the way up the sicula whereas in reality it has originated earlier; th. 1^2 is concavely curved like th. 1^1 but to a rather less extent, and therefore the aperture of th. 1^2 rises to a greater height than that of th. 1^1, though both thecæ have approximately the same length. The aperture of th. 1^1 is at a level of about 1·5 mm. above the sicular aperture, and lies at about 1·5 mm. from it sideways.

There are indications of the presence of a septum in the obverse aspect, but none in the reverse, so that it must be incomplete (Törnquist). Examples preserved in sub-relief show that it occasionally extends half way through the polypary.

The virgula is conspicuous and is often distally prolonged.

Affinities.—*P. minor* may be confused at first sight with young forms of *Petalog. palmeus* s.s. and var. *latus*, but it is distinguishable by the following characteristics: (1) the sicula is longer and attains a greater height within the thecal series than in *Petalog. palmeus* or in any of its varieties; (2) the proximal end is always more protracted; (3) the greatest width is reached later than in *Petalog. palmeus* or var. *latus*; (4) there is no trace of a septum in the reverse aspect as in *Petalog. palmeus*; (5) in *Petalog. minor* the distal end is gently rounded off and the polypary increases in width distally.

Horizon and Localities.—Birkhill Shales (zone of *Monog. gregarius*).

S. Scotland: Dobb's Linn (Long Cliff); Garple Linn; etc. *Lake District:* Skelgill. *Wales:* Rhayader; Twymyn Valley, Llanbrynmair; Afon Fadre, Pennant; Pary's Mountain, Anglesea.

Associates, etc.—*P. minor* is not an uncommon form in the zone of *Monog. gregarius*, but it is most abundant in that part corresponding with Marr and Nicholson's zone of *M. fimbriatus*, where it is found associated with *M. gregarius* and *M. fimbriatus*.

Collections.—Sedgwick Museum, Marr, and the Authors.

Petalograptus altissimus, sp. nov. Plate XXXII, figs. 7 *a*—*e*.

Polypary large, massive and thick, having a length 2—3 cm. and a maximum breadth of 4 mm. when compressed. Sicula long, septum incomplete. Thecæ ten in 10 mm., alternate, long tubes of the usual *Petalograptus* type, three times as long as wide, overlapping fully three quarters of their length; apertural margins slightly concave, everted.

Description.—The polypary is unusually robust, and, like that of all the *Petalograpti*, its breadth, which is attained by gradual widening, is great relative to its length; there is usually a slight diminution in width in the distal region.

The sicula is long and thin; in the obverse aspect it is seen to have a length of fully 2 mm.; th. 1^1 originates from above the aperture of the sicula, and grows outward and upward, while th. 1^2 develops from the latter in such a way as to conceal the whole structure in the initial part of the polypary in the reverse aspect, and give it the protracted *Petalograptid* character. The aperture of th. 2^2 reaches to the level of the apex of the sicula, where the septum commences.

FIGS. 194 *a*—*c*.—*Petalograptus altissimus*, sp. nov.

a. Obverse aspect, showing sicula; in full relief. Llanystwmdwy, near Criccieth. Tarannon Beds (zone of *M. turriculatus*). Coll. Fearnsides.
b. Distal thecæ, part preserved in relief, part as a cast; note partial septum. Ibid.
c. Distal thecæ, preserved as a cast; note absence of septum in reverse aspect. Ibid.

A transverse section of the polypary shows that the septum is very insignificant, extending inwards but a short distance from the obverse side. In the reverse aspect no trace of a septum is seen, but the alternate growth of the thecæ is often very beautifully shown.

The thecæ are long, narrow tubes, with curved walls, which are in contact for almost their whole length, and their flattened concave apertures are markedly oblique.

Affinities.—*P. altissimus* may be said to resemble all the other *Petalograpti* in

its general features; it is, however, distinguished from all forms hitherto described, by its larger size and greater thickness. From *Mesog. magnus*, to which it has some superficial resemblance, it may be separated readily on account of the totally different character of the thecæ of the proximal end.

Horizon and Localities.—Upper Birkhill Shales (zone of *Rastrites maximus*); Gala-Tarannon (zone of *Monog. turriculatus*).

S. Scotland: Dobb's Linn; Belcraig, etc. *Wales:* Llanystwmdwy; Pontbrendibyn, Llanbrynmair; two hundred yards south of Parbryn Sands, Cardiganshire.

Associates, etc.—*P. altissimus* occurs in some abundance in the above-mentioned zones in S. Scotland and Wales; it is commonly associated with *Rastrites maximus* and *Monog. turriculatus*. It is frequently preserved in relief.

Collections.—Lapworth, O. T. Jones, Fearnsides, and the Authors.

Petalograptus folium (Hisinger). Plate XXXII, figs. 8 *a*—*e*.

1837. *Prionotus folium*, Hisinger, Lethæa Suecica, Suppl., p. 114, pl. xxxv, fig. 8.

1843. *Prionotus folium*, Portlock, Geol. Rep. Londonderry, p. 321, pl. xx, fig. 5.

1880. *Diplograptus folium*, Törnquist, Geol. Fören. Förhandl., vol. v, p. 442, pl. xvii, fig. 7.

1882. *Cephalograptus folium*, Tullberg, Bihang till k. Svenska Vet.-Akad. Handl, vol. vi, no. 13, p. 15, pl. i, figs. 15—19.

1890. *Diplograptus folium*, Geinitz, Graptolithen des k. mineralog. Mus. Dresden, p. 26, pl. A, figs. 44—46.

1897. *Petalograptus folium*, Elles, Quart. Journ. Geol. Soc., vol. liii, p. 188, pl. xiii, figs. 1—5.

1897. *Diplograptus folium*, Törnquist, Diplogr. and Heteroprionidæ of Scanian *Rastrites* Beds, Acta Reg. Soc. Physiog. Lund., vol. viii, p. 12, pl. ii, figs. 1—4.

Polypary 1·5—2·5 cm. in length, narrow proximally but widening quickly to a breadth of 6 mm. opposite the apertures of the fourth pair of thecæ, and maintaining this width to the distal extremity, or continuing to widen almost imperceptibly up to 7 mm. Thecæ ten in 10 mm., inclined 5°—20°, about 7 mm. in length, six times as long as wide, overlapping two thirds or more; apertural margins concave, oblique, except at distal extremity, where they are horizontal.

Description.—The sicula has a length of about 2 mm.; it usually shows a virgella, and is generally visible for its entire length in the obverse aspect of the polypary; it is free for a fraction of its length on the right side. In the reverse aspect, only the base of the sicula and a very small portion of its side are visible, the rest being concealed by the initial part of the second and subsequent thecæ. Th. 1^1 originates a little way above the aperture of the sicula, and grows downward to a point slightly below it, then turning, grows slightly outward and upward. It is usually rather more than three times as long as the sicula, and attains a length of 7 mm.

The width of the polypary opposite the aperture of th. 1^1 varies from 3—4 mm.; it increases rapidly up to the level of the fourth pair of thecæ, but afterwards the increase is so slight that the sides appear approximately parallel for a distance proportionate to the length of the polypary; there is, however, a certain amount of variation in the width of the polypary, due to the amount of curvature of the thecæ; the greater the curvature, the greater the width.

The thecæ of the central portion of the polypary are fully 7 mm. in length, but they are somewhat shorter towards the distal end and those developed last are quite short; the average ratio between the length and breadth is 6 : 1. The angle at which they are inclined to the median line of the polypary varies; it is about 5° at the proximal end, increasing to 20° in the median portion, and decreasing again to 5° near the distal end. All the thecæ are concavely curved but not equally so; the curve is greatest in those developed earliest, but subsequently diminishes, giving to the whole polypary the characteristic foliate appearance to which it owes its name. The thecæ overlap for two thirds of their length, but this amount increases distally till the thecæ are in contact practically for their whole extent.

Fig. 195.—*Petalograptus folium* (His.).

Complete specimen, obverse aspect. Belcraig Burn, Birkhill Shales. Figured, Elles, Quart. Journ. Geol. Soc., vol. liii, pl. xiii, fig. 5. Brit. Museum (Nat. Hist.).

The appearance of rounding off at the distal end is due, as in *Phyllograptus*, to the decrease in curvature and diminution in length of the thecæ.

No indications of the presence of a septum have been detected in this species; the virgula takes a very irregular course, which seems to indicate that it was free inside the polypary. The virgular tube is often distally prolonged for a considerable distance, and is not infrequently split at one or more points along its length; it seems to have lain very near the obverse surface in the earlier part of its course.

Affinities.—*P. folium* is a highly characteristic species. It has long been well known in Scandinavia, but in Britain it has often been confused with *P. palmeus*, from which it may be distinguished by the following characteristics: (1) Its more pronounced foliate form; (2) its greater width; (3) the more protracted nature of the proximal end; (4) the longer thecæ, their lower angle of inclination, and the smaller number in a given unit of length.

Horizon and Localities.—Birkhill Shales (in the highest beds of the zone of *Monog. gregarius*, and in the zone of *Monog. convolutus*).

S. Scotland: Dobb's Linn; Belcraig Burn; Duffkinell Burn, etc. *Lake District:* Skelgill. *Ireland:* Coalpit Bay, Donaghadee.

Associates, etc.—*P. folium* is a fairly abundant form in S. Scotland in a band of shale at the top of the zone of *Monog. gregarius*, lying immediately below the

zone of *Cephalog. cometa.* In the Lake District it occurs in Marr and Nicholson's zone of *Monog. convolutus,* which occupies a corresponding systematic position. Its common associates are *Monog. gregarius, M. convolutus,* and *Glyptog. tamariscus.*

Collections.—Sedgwick Museum, British Museum (Natural History), Lapworth, and the Authors.

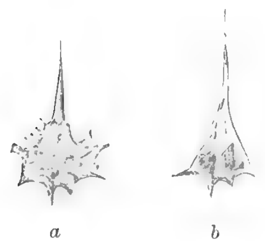
Petalograptus (?) phylloides, sp. nov. Plate XXXII, figs. 16 *a—e.*

Polypary very small, foliiform, not exceeding 5 mm. in length, and with an average breadth of 2·5—3 mm. Sicula very long, virgella conspicuous, first theca growing downwards for greater part of its length. Thecæ of the general *Phyllograptus* type, varying both in size and direction of growth in different parts of the polypary.

Description.—The polypary and general characters of the thecæ in this dwarf form strongly resemble those of a small *Phyllograptus,* but there are only two stipes instead of four. The polypary is in general twice as long as wide, though there is some slight variation in this respect.

The sicula is extremely long, and in all young stages projects distally beyond the polypary; it measures fully 3 mm. in length. Th. 1^1 arises from near the apex of the sicula (as in *Phyllograptus*), and grows downward for the greater part of its length, apparently bending slightly upwards in its apertural region. Th. 1^2, th. 2^1, th. 2^2, and th. 3^1 all grow horizontally, and only in the later thecæ does the upward direction of growth become marked.

FIGS. 196 *a* and *b.*—*Petalograptus (?) phylloides,* sp. nov.



a. Young specimen, showing sicula and earlier thecæ. Carrifran Burn, Moffat Water; Glenkiln Shales. Coll. Geol. Survey of Scotland, Edinburgh.

b. Younger stage (probably of same species), showing sicula and th. 1^1 and th. 1^2. On same slab as Fig. 196 a.

There are commonly five or six thecæ on each side, and the maximum breadth of the polypary is attained with the development of th. 3^1 and th. 3^2; thereafter with the change in the direction of thecal growth the width diminishes towards the distal extremity.

The apertural margins of the thecæ are very slightly concave when compressed, with their lower edges prolonged into sub-mucronate denticles. The thecæ are in contact throughout their length as in *Phyllograptus.*

Affinities.—*P. (?) phylloides* has long been known in the Glenkiln Shales of South Scotland, but has hitherto remained undescribed.

It resembles a dwarf *Phyllograptus* or *Petalograptus* in its general shape, and is here placed provisionally in the latter sub-genus for the purpose of reference. But in the mode of development of its initial portion the polypary not only recalls

that of the genus *Phyllograptus*, but also that of *Cryptograptus*. This biserial mimetic form may eventually be shown to belong to a new sub-genus which is related to *Didymograptus* as *Phyllograptus* is to *Tetragraptus* (*Mimograptus*, Lapw. MS.).

Horizon and Localities.—Glenkiln Shales.

S. Scotland : Belcraig; Dobb's Linn; Glenkiln Burn; Carrifran Burn.

Associates, etc.—*P.* (?) *phylloides* is of fairly common occurrence in a band in the *Nemag. gracilis* zone at Belcraig Burn, where it occurs associated with the zone fossil, *Dicellog. sextans, Orthog. Whitfieldi, Cryptog. tricornis*, etc. It has also been found, though less abundantly, at the Glenkiln Burn, and at Dobb's Linn, etc.

Collections.—Sedgwick Museum, Lapworth, and the Authors.

Group II. *Cephalograptus*, Hopkinson.

Petalograpti in which the polypary is triangular or fusiform, proximal end very protracted. Sicula largely exposed, completely visible in both obverse and reverse aspects. Septum incomplete. Thecæ approximately straight, with concave apertural margins which are horizontal in compressed examples.

Cephalograptus cometa (Geinitz). Plate XXXII, figs. 10 *a—d*.

1852. *Diplograpsus cometa*, Geinitz, Die Graptolithen, p. 26, pl. i, fig. 28.

1853. *Diplograpsus cometa*, Richter, Zeitschr. d. deutsch. geol. Gesellsch., vol. v, p. 457, pl. xii, figs. 16, 17.

1867. *Diplograpsus tubulariformis*, Nicholson, Geol. Mag., vol. iv, p. 109, pl. vii, fig. 15.

1868. *Diplograpsus cometa*, Carruthers, Geol. Mag., vol. v, p. 131, pl. v, fig. 4.

1869. *Cephalograptus cometa*, Hopkinson, Journ. Quek. Micros. Club, p. 159, pl. viii, fig. 14.

1873. *Cephalograptus cometa*, Lapworth, Geol. Mag., vol. x, p. 555, and Proc. Geol. Assoc., vol. iii, p. 167.

1876. *Cephalograptus cometa*, Lapworth, Cat. West. Scott. Foss., pl. ii, fig. 31.

1877. *Cephalograptus cometa*, Lapworth, Graptolites of Co. Down, p. 132, pl. vi, fig. 4.

1878—79. *Diplograptus cometa*, Törnquist, Geol. Fören. Förhandl., vol. iv, p. 456

1882. *Cephalograptus cometa*, Tullberg, Bihang till k. Svenska Vet.-Akad. Handl., vol. vi, no. 13, p. 15.

1890. *Diplograptus cometa*, Geinitz, Graptolithen des k. mineralog. Mus. Dresden, pl. A, fig. 47.

1893. *Cephalograptus cometa*, Törnquist, Structure of some Diprionidæ, Acta Univ. Lund., vol. xxix, p. 11, figs. 36—41.

1897. *Cephalograptus cometa*, Elles, Quart. Journ. Geol. Soc., vol. liii, p. 204, pl. xiii, figs. 10—16.

1897. *Diplograptus cometa*, Törnquist, Diplog. and Heteroprionidæ of Scanian *Rastrites* Beds, Acta Reg. Soc. Physiog. Lund., vol. viii, p. 14, pl. ii, figs. 8—14.

Polypary elongate, fusiform, acicular, 1—4 cm. in length, very slender proximally, but widening gradually to a maximum breadth of 2·5 mm., which is attained opposite the aperture of the first theca, maintaining this

width for a short distance, and narrowing thence in a distal direction. Sicula small. Thecæ always few in number, never exceeding twelve, with all the apertural margins situated close to the distal extremity and forming a kind of crown; very long, straight, narrow, and slightly curved tubes, inclined 5°—10°; apertural margins normal.

Description.—The sicula is completely visible (Törnquist) in both obverse and reverse aspects of the polypary. It is very small compared with the great length attained by the earliest thecæ, measuring only 1·5 mm.; when viewed in either aspect it is seen to be free for its entire length (as in all forms of the Monograptidæ).

Fig. 197.—*Cephalograptus cometa* (Geinitz).

Reverse aspect, showing sicula. Pary's Mountain, Anglesea; Llandovery Beds. Coll. G. J. Williams.

Th. 1^1 originates close to the aperture of the sicula, and grows upward, making a very gentle outward curve. Th. 1^2 does not develop from th. 1^1 till the latter has grown some considerable distance beyond the sicula, so that the latter is completely visible in both aspects of the polypary.

The virgula is seen to arise, as usual, from the apex of the sicula, but at first it runs along the dorsal side of th. 1^1, and appears subsequently to pass into the centre of the polypary. The virgular tube is often distally prolonged and not infrequently split at some point along its length.

The entire proximal end of the polypary is slender and is greatly protracted, the attenuation being especially marked at a short distance from the proximal extremity, at which point the polypary is frequently broken off. When the polypary is complete a slight swelling is observable at its extreme proximal end, indicating the position of the aperture of the sicula. The proximal portion of the polypary appears to have been somewhat flexible, for most compressed examples have a somewhat sinuous outline. The two thecæ earliest developed are very long and narrow; th. 1^1 may be as much as 3 cm. or more in length. All the thecæ subsequently developed are shorter than these.

Polyparies from different localities are apt to vary slightly in width, apart from considerations of preservation. The compressed specimens commonly found in Britain have a maximum width of about 2·5 mm. (usually attained opposite the aperture of th. 1^1), and this may be maintained up to the level of the aperture of th. 1^2 before decreasing; or a decrease in width may take place before the level of the aperture of th. 1^2 is reached. The thecæ are often somewhat curved, with the exception of those developed last, which are short and straight. Growth-lines may often be detected on specimens preserved in relief.

The septum is invisible (Törnquist) in the reverse aspect of the polypary; it is, in fact, so far reduced that it can scarcely be said to be more than a mere fold of the periderm on the obverse aspect. This median fold is not continued to the proximal end of the polypary.

Affinities.—The distinctive characters of the external form of this species led Hopkinson to found for its inclusion the sub-genus *Cephalograptus*, in order to separate it from the ordinary types of *Diplograpti*, though he did not recognise all its structural characteristics, which were fully worked out later by Törnquist.

C. cometa may be readily distinguished from all other *Petalograpti* except *Cephalog. tubulariformis* by the greatly protracted character of its proximal portion. From *C. tubulariformis*, which is also proximally prolonged, it may be distinguished by its fewer thecæ, the apertures of which are arranged so as to form a kind of crown at the distal extremity.

Horizon and Localities.—Base of the Upper Birkhill Shales, zone of *Cephalog. cometa*, immediately below that of *Monog. spinigerus.*

N. Wales: Pary's Mountain, Anglesea. *Lake District:* Browgill. *S. Scotland:* Dobb's Linn; Belcraig Burn; Hartfell; Duffkinell Burn; etc. *Ireland:* Coal-pit Bay, Donaghadee.

Associates, etc.—*C. cometa* occurs abundantly in a well-defined though narrow band immediately below the zone of *Monog. spinigerus* in S. Scotland, the Lake District, and Ireland, and is commonly associated with *Glyptog. tamariscus*, *G. sinuatus*, *Monog. convolutus*, *M. lobiferus*, *M. gregarius*, and *M. jaculum.*

Collections.—British Museum (Natural History), Sedgwick Museum, Mr. G. J. Williams of Bangor, Lapworth, and the Authors.

Cephalograptus tubulariformis (Nicholson). Plate XXXII, figs. 9 *a—d*.

1867. *Diplograpsus tubulariformis*, Nicholson, Geol. Mag., vol. iv, pl. vii, figs. 12, 13.
1897. *Cephalograptus petalum*, Elles, Quart. Journ. Geol. Soc., vol. liii, p. 206, pl. xiii, figs. 6—9.

Polypary wedge-shaped, from 1—2·5 cm. in length, very narrow proximally but widening quickly to a maximum breadth of 4 mm., which is attained opposite the apertures of the third pair of thecæ and thence maintained up to the distal extremity. Sicula small. Thecæ about eight in 10 mm., alternate, long straight tubes from 9—6 mm. in length, and about eight times as long as wide, inclined at 10°; apertural margins normal.

Description.—The whole proximal end is slender and protracted, but to a much lesser degree than in *Cephalog. cometa*, and it is usually quite straight. The position of the sicula strongly recalls that in the *Monograpti*, being entirely free on one side in both aspects of the polypary. It has a length of about 1·5 mm., and the virgella, which is sometimes visible, may measure at least 3 mm. in length. Th. 1^1 arises slightly above the aperture of the sicula, and describing an outward curve attains a length of about 9 mm.; th. 1^2 develops from th. 1^1 immediately after it has gone beyond the level of the apex of the sicula.

The virgula has a similar course to that described for *C. cometa*, and the virgular tube is often prolonged beyond the distal extremity of the polypary.

FIG. 198.—*Cephalograptus tubulariformis* (Nich.).

Obverse aspect, showing sicula. Enlargement of part of Pl. XXXII, fig. 9 *d*.

The thecæ are alternate in their arrangement, and their length decreases steadily from the proximal to the distal extremity of the polypary; they overlap about two thirds their extent at first, but this amount decreases in a distal direction. They average eight in 10 mm., and are not all collected together near the distal end of the polypary as in *Cephalog. cometa*, but range down the ventral side of the polypary for fully half its extent. The average inclination of the thecæ is about 10° in the middle of the polypary, but the amount of inclination decreases both in the proximal and distal regions. The apertural margins are but slightly everted.

There are no indications of the presence of a septum.

Affinities.—This species was one of three included by Nicholson in his original description of *Diplograptus tubulariformis*. As first pointed out by Elles ('Quart. Journ. Geol. Soc.,' 1897) an examination of his type specimens shows that the specimens from which his figs. 12 and 13 were drawn is the species described by her as *Cephalog. petalum*, while fig. 14 represents a young *Petalog. folium*, and fig. 15 a *Cephalog. cometa*. As figs. 12 and 13 are the first two figures employed by Nicholson to illustrate his species, his name for it is here revived.

C. tubulariformis is in all respects an intermediate form between the *Cephalograpti* and the *Petalograpti*. The mature polypary varies exceedingly in shape, some specimens approaching very nearly to *Petalog. folium*, others resembling more closely *Cephalog. cometa*. The characters of the proximal end are always more like those of *Cephalog. cometa* than those of *Petalog. folium*, but, on the other hand, the thecæ in the distal portion of the polypary are more like those of the latter than those of the former. It may therefore be readily distinguished from either species.

Horizon and Localities.—Lowest beds of Upper Birkhill Shales (base of zone of *Cephalog. cometa*).

S. Scotland: Duffkinell Burn; Belcraig Burn; Dobb's Linn; Frenchland Burn. *Ireland:* Coalpit Bay, Donaghadee.

Associates, etc.—*C. tubulariformis* is a somewhat rare fossil in the Upper Birkhill Shales of S. Scotland, where it occurs at the base of the zone of *Cephalog. cometa*; it is rather more abundant at the same horizon in the shales of Coalpit Bay.

Collections.—British Museum (Natural History) (Nicholson's original specimens), Sedgwick Museum, and the Authors.

Cephalograptus (?) acuminatus (Nicholson). Plate XXXII, figs. 11 *a—d*.

1867. *Diplograptus acuminatus*, Nicholson, Geol. Mag., vol. iv, p. 109, pl. vii, figs. 16, 17.
1897. *Diplograptus acuminatus*, Törnquist, Acta Reg. Soc. Physiog. Lund., vol. viii, p. 14, pl. ii, figs. 5—7.

Polypary 1—3 cm. in length, straight or slightly curved, increasing gradually from a narrow protracted proximal extremity to a maximum breadth of 1·5 mm., which is maintained up to the distal extremity. Sicula very long and slender. Thecæ approximating to the *Glyptograptus* type, about ten in 10 mm., long narrow tubes with an average length of 2—2·5 mm., inclined at 20°; outer walls with sigmoid curvature, overlapping one half their length; apertural margins introverted, with acute denticle when compressed.

Description.—The proximal end is protracted, the maximum width of the polypary being attained about 1 cm. from the proximal extremity. The sicula has a length of 2·5 mm. and is very slender; it is usually free for almost its entire length on one side in both aspects of the polypary, the extreme apical part being all that is embedded. The virgella is short, never exceeding 1 mm. in length, and is only rarely preserved. The virgula is sometimes seen to be distally prolonged.

FIG. 199.—*Cephalograptus* (?) *acuminatus* (Nicholson).

Complete young specimen, obverse aspect. Dobb's Linn, Lower Birkhill Shales. Coll. Sedgwick Museum.

Th. 1^1 originates from a point about 1 mm. above the aperture of the sicula, and grows almost straight upward at once, attaining a length of 2 mm. or more; th. 1^2 buds from th. 1^1 at about the level of the apex of the sicula, and, growing straight outward and upward, attains a length slightly less than that of th. 1^1.

The thecal apertures are introverted, with an acute denticle when compressed; but in specimens preserved in relief the apertures are nearly straight and not so obviously acuminate. Growth-lines parallel to the apertures may occasionally be detected, and a complete septum always appears to be present.

Affinities.—The systematic place of *Cephalog.* (?) *acuminatus* is uncertain. In the general characters of the thecæ it certainly differs from any other *Cephalograptus* or *Petalograptus* as yet described, and comes nearer the *Glyptograpti*; while, as regards the character of the proximal end it clearly approaches the *Dimorphograpti*, though it is still a Diplograptid.

We place it provisionally with the *Cephalograpti* on account of its resembling

Specific Characters of Forms belonging to the Sub-genus ORTHOGRAPTUS.

GROUP I.

	Orthog. quadrimucronatus.	var. *spinigerus.*	*O. pageanus.*	var. *micracanthus.*	var. *abnormispinosus.*	*O. Whitfieldi.*	*O. insectiformis.*	*O. vesiculosus.*	var. *penna.*	*O. bellulus.*	*O. mutabilis.*
Character of polypary	Long and broad, widening gradually	Larger than typical form, with abnormal spines on 10th thecal pair	Relatively short and fusiform	Short, and widening rapidly	Short, with abnormal spines on 8th or 9th thecal pair	Short and relatively wide	Very small	Very robust, with broad vesicle at distal extremity	Smaller and narrower than typical form, with less conspicuous vesicle	Short and somewhat robust	Large and widening rapidly
Maximum width	3 mm.	—	4·5 mm.	2·5–3 mm.	—	3 mm.	1·5	3—4 mm.	2·5 mm.	2 mm.	3—3·5 mm.
Virgula	Inconspicuous	—	Conspicuous, wire-like	—	Tubular	Conspicuous	?	Delicate, seen within vesicle	—	Slender	?
Character of proximal end	Narrow	—	—	—	—	—	—	Broad	—	Wide	Rapid increase in breadth
Length of sicula	1·5 mm.	—	?	?	?	1 mm., with conspicuous virgella	2 mm.	Very large, 6 mm. (?)	—	Small, ·5 mm., long virgella	2 mm., with slender virgella
Characters of thecæ: 1. No. in 10 mm.	12—8	10—8	16—12	—	14—10	12	12—10	10—8	—	14—10	12—9
2. Overlap	$\frac{1}{3}$–$\frac{1}{2}$	—	—	—	—	—	$\frac{1}{2}$–$\frac{2}{3}$	$\frac{1}{2}$	—	—	$\frac{1}{2}$–$\frac{2}{3}$
3. Apertural margin	Slightly lobate, thickened	—	Conspicuously lobate	—	—	Sub-lobate, thickened	Slightly lobate	—	—	Slightly undulate, wide	Slightly lobate, with flange
4. Ornamentation	Short stiff spines	—	Flexed spines	—	—	Slender stiff spines directed upward	Spines delicate and flexed	None	—	—	—

Specific Characters of Forms belonging to the Sub-genus ORTHOGRAPTUS—continued.

	GROUP II.						GROUP III.						
	O. truncatus.					*O. cyperoides.*	*O. calcaratus.*						*O. rugosus.*
		var. *abbreviatus.*	var. *intermedius.*	var. *pauperatus*	var. *socialis.*			var. *vulgatus.*	var. *acutus.*	var. *basilicus.*	var. *tenuicornis.*	var. *priscus.*	var. *apiculatus.*
Character of polypary	Robust, fusiform	Short, sub-fusiform or widening throughout	Very long and relatively narrow	Short and narrow	Very small	Very small and slender	Robust, wide, with 3 conspicuous basal spines	Coarser and widening more abruptly than typical form: devoid of basal spines	Relatively broader than var. *vulgatus*	Narrower and more compact	With long, slender basal spines	Very long and relatively broad, widening gradually	Medium length, widening rapidly
Maximum width	4 mm.	3 mm.	2·5 mm.	2 mm.	1·5 mm.	1 mm.	2·5—3·5 mm.	—	—	2·5 mm.	—	5 mm.	3·5 mm.
Virgula	?	?	?	?	?	—	Virgular tube stout and long	—	Inconspicuous, slender	—	Virgular tube slender	Inconspicuous	—
Character of proximal end	Gradual widening	—	—	—	—	Slightly protracted	3 large spines	No spines	—	—	3 slender spines	Broadly truncate	Narrow
Length of sicula	2·5 mm., with conspicuous virgella	—	—	—	2 mm.	Very long: 3 mm.	Unknown, virgella very long and conspicuous	?	?	2 mm.	? virgella short and inconspicuous	Virgella short and stout	1·5 mm., virgella stout
Characters of thecæ: 1. No. in 10 mm.	13—10	—	14—10	14—12	—	12	10—8	—	12—9	11—9	—	14—10	12—8
2. Overlap	$\frac{1}{2}$—$\frac{2}{3}$	—	—	$\frac{1}{2}$	$\frac{1}{3}$—$\frac{1}{2}$	Slight	Not exceeding $\frac{1}{2}$	—	—	—	—	$\frac{1}{2}$—$\frac{2}{3}$	$\frac{1}{2}$
3. Apertural margin	Slightly undulate, everted		Less everted, approaching that of *Glyptograptus*	Like typical form	Somewhat less everted than typical form	Slightly undulate and slightly everted	Strongly lobate	More everted than typical form	More everted with flange	Projecting but slightly from ventral margin	Like typical form	Inconspicuous, slightly lobate	Wide, straight, and mucronate
4. Ornamentation	Small spines on basal thecæ only	—	—	—	—	—	Conspicuous spines on basal thecæ only	None	—	—	Slender and long spines on basal thecæ only	Small spines on basal thecæ only	—

Specific Characters of Sub-genus GLYPTOGRAPTUS.

	GROUP I.									GROUP II.	
	G. tamariscus.	var. *incertus.*	*G. serratus.*	var. *barbatus.*	*G. teretiusculus.*	var. *englyphus.*	var. *siccatus.*	*G. dentatus.*	var. *appendiculatus.*	*G. sinuatus.*	*G. persculptus.*
Character of polypary	Long and narrow	Wider and shorter than typical form	Long, and relatively broad, widening rapidly at first	Slightly more robust	Long, and widening gradually	Longer and more tapering than typical form	Very small and narrow	Short and rather broad relatively	Like typical form, but furnished with flattened vesicle at distal end	Thick, small, widening very abruptly at first	Medium length widening quickly
Maximum width	1 mm.	2 mm.	3·5 mm.	—	2 mm.	—	1 mm.	2 mm.	—	2 mm.	2—2·5 mm.
Length of sicula	1 mm., virgella long	—	?	—	1·5 mm., with long virgella 3 mm.	—	—	1 mm. ?	—	1 mm. ?; virgella very long and conspicuous	2·1 mm.; virgella small
Characters of thecæ: 1. No. in 10 mm.	14—12	—	14—8	—	14—10	11—10	—	18—12	—	12—10	10—8
2. Overlap	Slight, $\frac{1}{4}$–$\frac{1}{3}$	Fully $\frac{1}{2}$	$\frac{1}{3}$–$\frac{1}{2}$	—	$\frac{1}{2}$	—	—	Slight	—	$\frac{1}{2}$	—
3. Apertural margin	Even, or very slightly undulate, introverted	—	Slightly undulate	—	Slightly undulate and often markedly introverted	—	—	Sub-lobate, introtorted	—	Slightly undulate and everted	Slightly undulate, everted, and introtorted
4. Ornamentation	None	—	—	Long, downward curved spines on all proximal thecæ	Small spines on basal thecæ only	None	—	Small spines on proximal thecæ	—	None	—

Specific Characters of Sub-genus MESOGRAPTUS (*including* AMPLEXOGRAPTUS).

	MESOGRAPTUS—GROUP I.							MESOGRAPTUS—GROUP II (AMPLEXOGRAPTUS).			
	M. foliaceus.	*M. multidens.*	var. *compactus.*	*M. modestus.*	var. *parvulus.*	var. *diminutus.*	*M. magnus.*	*A. perexcavatus.*	*A. confertus*	*A. celatus.*	*A. arctus.*
Character of polypary	Short, parallel-sided	Robust, widening rapidly. Virgula a flattened tube	Narrower than typical form	Small, but relatively robust, widening rapidly. Virgula conspicuous	Very short, but otherwise resembling young *modestus*	Small	Robust, widening for half the length	Short and fairly broad	Small parallel-sided	Fairly long, widening rapidly. Virgula conspicuous	Small, widening imperceptibly
Maximum width	3 mm.	3·5—4 mm.	3 mm.	3 mm.	—	1·5 mm.	4 mm.	2—2·5 mm.	1—2 mm. (uniform)	3·2 mm.	1 mm.
Length of sicula	1 mm. ?	1 mm.	—	1 mm.	—	—	2 mm.	2 mm., virgella conspicuous	1 mm. (?), virgella slender	? Virgella of considerable length	1·5 mm., virgella very long
Characters of thecæ: 1. No. in 10 mm.	14—12	18—14	14—12	—	—	16—14	14—12	16—12	—	10—8	14—10
2. Overlap	$\frac{1}{2}$–$\frac{2}{3}$	$\frac{2}{3}$–$\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{3}$–$\frac{1}{2}$	—	—	$\frac{1}{2}$–$\frac{2}{3}$	$\frac{1}{2}$	—	?	Not exceeding $\frac{1}{2}$
3. Apertural margin, etc.	Slightly undulate, concave	(*a*) concave, horizontal; (*b*) everted	—	Wide, undulate	—	—	Undulate, narrow, concave, and everted	Slightly concave and oblique. Excavation deep and wide	Concave, oblique, denticle sharp. Excavations deep and oblique	Undulate. Excavations short and shallow	Somewhat introverted. Excavation fairly conspicuous
4. Ornamentation	Conspicuous, small, unsymmetrically (?) disposed spines on basal thecæ only	—	—	None	—	—	—	Small and distinct spines on basal thecæ only	—	?	Conspicuous spines on basal thecæ only

Specific Characters of Sub-genus PETALOGRAPTUS (*including* CEPHALOGRAPTUS).

	PETALOGRAPTUS—GROUP I.									PETALOGRAPTUS—GROUP II (CEPHALOGRAPTUS).		
	P. palmeus.				*P. ovatus.*	*P. minor.*	*P. altissimus.*	*P. folium.*	*P.* (?) *phylloides.*	*C. cometa.*	*C. tubulariformis.*	*C.* (?) *acuminatus.*
		var. *latus.*	var. *tenuis.*	var. *ovato-elongatus.*								
Character of polypary	Small, widening rapidly; margins sub-parallel	Small, wide	Small and uniformly narrow	Fusiform	Very small, circular in form	Short, oval, widening gradually	Massive, long	Medium length, widening quickly	Very small	Elongate, acicular	Wedge-shaped	Straight or slightly curved, widening gradually
Maximum width	2·5—3 mm.	4—5 mm.	1·5 mm., uniform	4·5 mm.	Variable	3 mm.	4 mm.	6 mm.	2·5—3 mm.	2·5 mm.	4 mm.	1·5 mm.
Septum	Present	—	—	Incomplete till 4th thecal pair	?	Incomplete	—	?	?	Incomplete	?	?
Character of proximal end	Slightly protracted	—	—	—	Very slightly protracted	Protracted	Slightly protracted	Distinctly protracted	Not protracted	Very protracted	Less protracted than *C. cometa*	Slightly protracted
Length of sicula	2 mm.	—	—	—	1·5 mm.	Very long, 3 mm.	2 mm.	2 mm.	Very long, 3 mm.	1·5 mm.	1·5 mm.	2·5 mm.
Characters of thecæ: 1. No. in 10 mm.	12—14	14—16	12	—	28	12	10	10	10—12	Very long and few in number	8	10
2. Overlap	$\frac{2}{3}$	—	$\frac{1}{2}$	Variable	Contact throughout	$\frac{2}{3}$–$\frac{3}{4}$	$\frac{3}{4}$	$\frac{2}{3}$	Contact throughout	Contact for almost entire length	$\frac{2}{3}$	$\frac{1}{2}$
3. Inclination	35°	45°—20°	35°	45°—20°	90°	45°	35°	5°–20°	Variable	5°—10°	10°	20°
4. Relative length and breadth	3 : 1	3 : 1	2 : 1	4 : 1	6 : 1 (?)	$4\frac{1}{2}$: 1	3 : 1	6 : 1	3 : 1 (?)	20 : 1 (?)	8 : 1	6 : 1

the typical forms of the sub-group in the marked protraction of the proximal part of the polypary.

The general characters of the thecæ with their acuminate margins should be sufficient to distinguish *C. acuminatus* from the other species here grouped as *Cephalograpti.*

Horizon and Localities.—Lower Birkhill Shales (zone of *C.* (?) *acuminatus*).

S. Scotland: Dobb's Linn; Duffkinell Burn; Garple Linn; etc. *Lake District:* Browgill.

Associates.—*Cephalog.* (?) *acuminatus* is a common fossil in the lowest beds of the Birkhill Shales wherever they are developed; it is commonly associated with *Climacog. normalis.*

Collections.—Sedgwick Museum, Marr, Lapworth, and the Authors.

Genus **CRYPTOGRAPTUS**, *Lapworth.*

1880. *Cryptograptus*, Lapworth, Ann. Mag. Nat. Hist. [5], vol. iv, p. 174.

Polypary concavo-convex, bilaterally symmetrical, biserial, and of uniform breadth throughout. Test delicate and (?) punctate.

Thecæ rhomboidal, short, inclined at a high angle, with sharp sigmoid curvature in apertural region only; apertural margins strongly everted, but lying within the general ventral margin.

One of the most characteristic features of the *Cryptograptus* polypary is its uniformity in breadth throughout its length, but, as a result of its concavo-convex section, the appearance when compressed is very different in the obverse and reverse aspects. In the obverse aspect the thecal apertures can be made out as a general rule, and the polypary appears somewhat narrower than when viewed from the reverse aspect, when the only trace of the presence of thecæ that can be detected is the crenulation of the ventral margin.

The thecæ are peculiar; they are inclined to the general direction of the polypary at a high angle for the greater part of their length, but exhibit sharp sigmoid curvature in the immediate region of the aperture, so that for a very short distance the thecal axis lies parallel to the axis of the polypary in a similar manner to that characteristic of the thecæ of the majority of *Climacograpti.* The free edge of each, however, is exceptionally short, and the apertural margin instead of being horizontal is strongly everted. From the lower end of the free edge of the thecæ a spine may be given off. The free edge is so short that in greatly compressed specimens it shows merely as a rounded knob or denticulation (*C. tricornis*), or, where the thecæ are spinose, it is drawn out and apparently merged with the spine itself (*C. Hopkinsoni*).

The mode of development of the earlier thecæ is in all essentials similar to that in the Diplograptidæ; but th. 1^1, and occasionally th. 1^2, grow almost vertically downward for the greater part of their length and only bend upward in the immediate region of the aperture. In this respect the *Cryptograpti* show an approach to the mode of development of some of the Dichograptidæ (*Phyllograptus*).

The test is remarkably attenuated, and in this respect seems to indicate an approach to that of the Glossograptidæ. In some examples it has the appearance of being punctate.

The type species of *Cryptograptus* is *C. tricornis*, and there can be little doubt that Nicholson's *Diplograptus Hopkinsoni* really belongs to the same genus; it is probable also that the forms from the Skiddaw Slates referred to *Climacog. antennarius* by many authors should also be included, though they are so indifferently preserved that it is not possible to be certain of this. The known British forms of *Cryptograptus* are:

Cryptog. tricornis.	*C. Hopkinsoni.*
var. *Schäferi.*	*C.* (?) *antennarius.*

Cryptograptus tricornis (Carruthers). Plate XXXII, figs. 12 *a—d*.

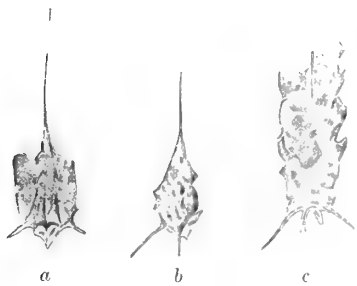
1859. *Diplograpsus tricornis*, Carruthers, Ann. Mag. Nat. Hist. [3], vol. iii, p. 25.
1859. *Graptolithus marcidus*, Hall, Pal. New York, p. 514, figs. 1, 2, 3.
1867. *Diplograpsus tricornis*, Carruthers, Intell. Observer, p. 290, pl. i, figs. 7, 8, 10.
1872. *Diplograptus Etheridgii*, Hopkinson ?, Geol. Mag., vol. ix, p. 504, pl. xii, figs. 5 *a—e*.
1875. *Diplograptus tricornis*, Lapworth, Quart. Journ. Geol. Soc., vol. xxxi, p. 658, pl. xxxv, figs. 6 *a* and *b*.
1876. *Diplograptus tricornis*, Lapworth, Cat. West. Scott. Foss., pl. ii, fig. 39.
1877. *Diplograptus tricornis*, Lapworth, Proc. Belfast Nat. Field Club, p. 132, pl. vi, fig. 10.
1880. *Cryptograptus tricornis*, Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, p. 171, pl. v, fig. 27 *a—e*.
1908. *Cryptograptus tricornis*, Ruedemann, Grapt. of New York, pt. 2, p. 443, pl. xxviii, figs. 1—4, and text-figs. 410—422.

Polypary, with very attenuate test, 2—4 cm. in length, widest at base, having a maximum width of 1·5 mm., but typically narrower. Sicula very long, 3 mm. in length. Virgella and straight lateral spines conspicuous. Thecæ eleven in 10 mm., about 1 mm. in length, overlapping one half their extent, with very short free edge, occasionally rounded off; apertural edges everted, giving an appearance of crenulation to ventral margin of polypary.

Description.—The dimensions and general appearance of the polypary vary considerably according to the direction of compression. In the obverse aspect the polypary rarely exceeds 1 mm. in width, and the thecal apertures can, as a rule, be clearly seen, but the spines at the base are not conspicuous. In the reverse aspect the polypary is frequently 1·5 mm. in breadth, no thecal apertures can be

detected, and the position of the thecæ themselves can only be inferred from the crenulation of the ventral margin; the virgella and lateral spines, however, stand out very clearly in this aspect.

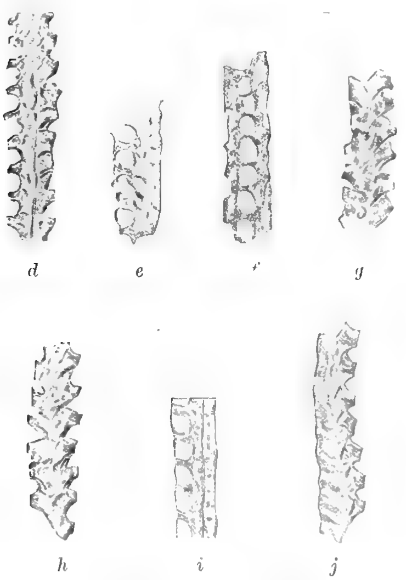
Figs. 200 *a—c.*—*Cryptograptus tricornis* (Carruthers).



a. Young example, obverse aspect, showing sicula and th. 1^1 and th. 1^2 with basal spines. On same slab as Pl. XXXII, fig. 12 *c*.
b. Young example, reverse aspect, on same slab as Fig. 200 *a*.
c. Proximal end showing two sicular spines in addition to those of th. 1^1 and th. 1^2. The Cornice, Hartfell; Hartfell Shales. Coll. Lapworth.

The characters of the proximal end are very obscure in adult specimens, but from young examples, which are fairly abundant, it can be seen that the sicula was very long, being fully 3 mm. in length. Its apertural edge is thickened and it possesses at least two spines. Th. 1^1 arises from near the apex of the sicula and grows vertically downward parallel to the sicula for practically the whole of its length; there seem to be indications, however, of an upward direction of growth close to the apertural region. A stiff long spine (from 1·5—2 mm. in length) is given off from the point where this apparent change in direction of growth takes place. Th. 1^2 appears to originate from th. 1^1 and to grow upward and outward. It possesses a spine similar in size and position to that of th. 1^1. The growth of the subsequent thecæ seems to be entirely upward.

Figs. 200 *d—j.*—*Cryptograptus tricornis* (Carr.).



200 *d—j.* Specimens in low relief, showing the various appearances presented by the thecæ in different views. Laggan Gill, Girvan; Ardmillan Series. Figs. *d—g* on same slab. Coll. Lapworth.

In the majority of compressed examples only three basal spines are presented—one central (from the sicula) and two lateral (one each from th. 1^1 and th. 1^2), and it was the presence of these which suggested the specific name. Occasionally, however, specimens are met with which show four or even five basal spines. Whether th. 1^1 and th. 1^2 each possessed a pair of spines or whether the aperture of the sicula was provided with more than two spines (comp. Ruedemann) is uncertain from our British examples.

The test of the polypary seems to be reduced to a mere film and is possibly punctate.

The thecæ assume very different appearances (Lapworth, 1880, *loc. cit.*). In the obverse aspect they may appear quite normal, with the short free edge and everted aperture showing clearly (Fig. 200 *j*), but if much compressed the free edge seems to be squeezed out into a knob (Fig. 200 *d*) or occasionally may even be drawn out to appear submucronate (ibid.); while in the reverse

aspect the thecæ either show as mere crenulations in the ventral margin or seem almost obliterated as the result of compression (Pl. XXXII, fig. 12 *b*). It is highly characteristic of this species that when preserved in relief the two ventral sides are never alike in appearance (Figs. 200 *d*—*j*). In scalariform views (Figs. 200 *f* and *i*) the large size of the apertures compared with that of the free outer edge of the theca is very obvious. These details can only be made out in specimens in low relief, and it is therefore not surprising to find that the different views of this form have been regarded as distinct species by earlier authors; such forms as Hall's *Graptolithus marcidus* and Hopkinson's *Diplog. Etheridgii* are now generally admitted (comp. Ruedemann) to be only differently presented specimens of *Cryptog. tricornis*.

Affinities.—*Cryptog. tricornis* can be readily identified. It is a far more slender and delicate form than any other *Cryptograptus* yet recognised.

Horizon and Localities.—Upper Arenig, Llandeilo - Bala, Glenkiln - Hartfell (especially in zones of *Dicellog. patulosus* and *Climacog. Wilsoni*).

S. Scotland: Hartfell; Dobb's Linn; Tottleham's Burn, Castle Douglas; Berrybush Burn, St. Mary's; Birnock, Abington; Laggan Gill, Girvan, etc. *Wales:* Nant yr Orlof, Penmorfa; Arenig; Tiddyndicwm; Abereiddy Bay; Porthhayog, Ramsey Island; Blaen-y-delyn Quarry, near Fishguard. *Ireland:* Coalpit Bay, Donaghadee; Ballygrot, Co. Down; Craigavad, Co. Down; Derrynaclough, Connemara.

Associates, etc.—*C. tricornis* is an abundant fossil in the Upper Llandeilo and Lower Bala rocks and their equivalents, but it is very rarely well preserved owing to the delicate nature of its test. The best specimens are those from Laggan Gill in the Girvan district, where it occurs in low relief in the transition zone between the Balclatchie and Ardwell Groups; these forms are invariably small. In the beds of Arenig age it occurs associated with *Didymog. bifidus* and also with *D. extensus*. In the Lower Llandeilo it is found at Abereiddy Bay in tolerable abundance associated with *Didymog. Murchisoni*; in the higher Llandeilo (Glenkiln) beds it occurs in profusion, associated with *Dicranog. ziczac*, *Dicellog. patulosus*, and *Climacog. peltifer;* it is also abundant in the overlying basal zone (*Climacog. Wilsoni*) of the Hartfell Shales (Bala), associated with *Climacog. Scharenbergi*, and *Dicranog. Nicholsoni*, and has also been found in the succeeding zone of *Dicranog. Clingani*.

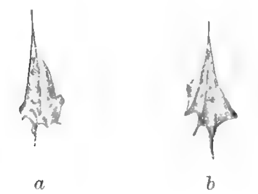
Collections.—Geological Survey of Scotland, Sedgwick Museum, H. B. Muff and R. G. Carruthers, Lapworth, and the Authors.

Var. **Schäferi**, Lapworth. Plate XXXII, figs. 13 *a—c*.

1880. *Cryptograptus tricornis* var. *Schäferi*, Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, pl. v, figs. 28 *a* and *b*.

A well-marked variety of *Cryptog. tricornis* is fairly common in the Llandeilo beds of certain localities. It was figured in 1880 by Lapworth as var. *Schäferi*, but has not hitherto been described. This variety is somewhat wider than the typical form in the obverse aspect (perhaps therefore the polypary was somewhat less concavo-convex), and the extremely short free edges of the thecæ are produced into distinctly mucronate extensions, but there are no conspicuous basal spines.

FIGS. 201 *a* and *b*.—*Cryptograptus tricornis*, var. *Schäferi*, Lapw.



a. Young stage, showing sicula and th. 1¹; reverse aspect. On same slab as Pl. XXXII, fig. 13 *c*.
b. Somewhat older stage showing sicula and th. 1¹ and th. 1²; obverse aspect. On same slab as fig. 200 *a*.

The downward direction of growth of th. 1¹ is very marked in this variety, and it would appear (Fig. 201 *b*) that th. 1² also grew downward. It is not known at what point the upward direction of growth commences.

Horizon and Localities.—Llandeilo, Glenkiln Shales.

Wales: Llandeilo; Abereiddy Bay; behind Pencerrig House, near Builth; Gwern-y-fed-fach, Builth; Llandrindod. *S. Scotland:* Tottleham's Burn, Urr Water; Kirriemore Burn, Minnoch Water.

Associates, etc.—Var. *Schäferi* occurs in fair abundance in the Builth District at various localities north of Llandrindod Wells associated with *Dicellog. sextans*, *Nemag. pertenuis*, and *Thysanog. retusus*.

Collections.—Sedgwick Museum, Lapworth, and the Authors.

Cryptograptus Hopkinsoni (Nicholson). Plate XXXII, figs. 15 *a* and *b*.

1869. *Diplograptus Hopkinsoni*, Nicholson, Ann. Mag. Nat. Hist. [4], vol. iv, p. 234, pl. xi, fig. 7.
1898. *Cryptograptus Hopkinsoni*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 520.

Polypary robust, 1—2 cm. in length, with average uniform breadth of 2 mm., base adorned with two long curved spines. Thecæ ten in 10 mm., of general *Cryptograptus* type but with free edges of all thecæ provided with spines.

Description.—The polypary in *Cryptog. Hopkinsoni* is relatively wide, apart from the spines which give it still greater apparent breadth; it is commonly small, not exceeding 2 cm. in length.

The thecæ are of the same general type as those of *Cryptog. tricornis*, but a spine grows out from the lower end of the short free edge of each theca, and is often so stout that when compressed it seems as if the denticle itself were drawn out into a spine; in less compressed examples, however, the true origin is clear. These thecal spines may have a length of fully 2 mm., while those belonging to th. 1^1 and th. 1^2 (the basal spines) are about 5 mm. long and are gracefully curved.

The test appears to be attenuate, but to be thicker than in *C. tricornis*.

Affinities.—*C. Hopkinsoni* differs from *Cryptog. tricornis* in the greater length of the curved basal spines, and in the fact that all the thecæ have ventral spines; the polypary also is wider in proportion to its length.

Horizon and Localities.—Middle and Upper Skiddaw Slates.

Lake District: Outerside; Bannerdale Fell; Glenderamakin Valley.

Associates, etc.—*Cryptog. Hopkinsoni* has, up to the present, only been recorded from the Skiddaw Series; where it occurs associated with *Tetrag. quadribrachiatus* in the Middle Skiddaw Slates and with *Didymog. indentus* in the Upper Skiddaw Slates. It is not an abundant fossil. The type specimen is in the British Museum Collection.

Collections.—British Museum (Nat. Hist.) and Sedgwick Museum.

Cryptograptus (?) antennarius (Hall). Plate XXXII, figs. 14 *a—e*.

1865. *Climacograptus antennarius*, Hall, Grapt. Quebec Group, p. 112, pl. xviii, figs. 11—13.
1868. *Diplograpsus antennarius*, Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 139.
1870. *Climacograptus antennarius*, Nicholson, Ann. Mag. Nat. Hist. [4], vol. vi, p. 382, fig. 6.
1898. *Cryptograptus* (?) *antennarius*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 519, fig. 31.
1904. *Climacograptus* (?) *antennarius*, Ruedemann, Grapt. New York, pt. i, p. 721, pl. xvi, figs. 21—26.

Polypary robust, 1·5—2·5 cm. in length, with an average uniform breadth of 2 mm. Virgella small but usually conspicuous; basal spines long, stiff. Thecæ, ten to eleven in 10 mm., unknown except as sub-scalariform impressions or as crenulations of the ventral margin.

Description.—All the British specimens of *C. antennarius* come from the Skiddaw Slates, and are badly preserved, so that the thecæ are never well seen. The general form of the polypary, the sub-horizontal position of the basal spines, and the concealed thecæ all point in the direction of *Cryptograptus*, to which genus we believe the form belongs, though it may be a *Climacograptus*.

The long basal spines form the most conspicuous characteristic of this species; as a rule, two only are seen, but not infrequently three are present, and it seems almost certain that there were four, th. 1^1 and th. 1^2 each being furnished with a pair. These spines are all stiff, approximately rigid, and fairly stout; they may measure 8·7 mm. in length.

In one specimen spines similar to the basal ones are seen proceeding from a thecal pair situated higher up the polypary.

Affinities.—*C. antennarius* may be readily separated from all other *Cryptograpti* by the long, stiff spines at its proximal end; these are much longer and stouter than those found in *Cryptog. tricornis*, and the whole character of the polypary is more robust.

Horizon and Localities.—Upper Skiddaw Slates.

Lake District: Outerside; Mungrisedale; Glenderamakin Valley; Mosedale Beck, near Troutbeck; Bannerdale Fell.

Associates, etc.—*C. antennarius* is a fairly common fossil in the Upper Skiddaw Slates, associated with *Didymog. indentus*. It is, however, invariably poorly preserved.

Collections.—British Museum (Natural History), Sedgwick Museum, Keswick Museum.

Genus **TRIGONOGRAPTUS**, *Nicholson.*

1869. *Trigonograpsus*, Nicholson, Ann. Mag. Nat. Hist. [4], vol. iv, p. 232.

Polypary bilaterally symmetrical, biserial throughout, transverse section concavo-convex or trigonal, ventral edges having the appearance of being even and continuous.

Thecæ resembling those of *Phyllograptus* and *Retiolites.*

Test thick, membranous, with transverse growth-lines.

The genus *Trigonograptus* was founded by Nicholson to include certain Graptolites found in the Skiddaw Slates of the Lake District. The thecæ are generally well marked, and appear to be sub-rectangular tubes expanding towards their apertures, and overlapping for the whole of their extent. They not only recall those of *Phyllograptus* but also those of *Retiolites.*

The transverse section of the polypary was probably strongly concavo-convex or even trigonal, and the appearance of the thecæ varies very much in different views.

Only one species and a variety are known with certainty in the British Isles—*Trigonograptus ensiformis* and var. *lanceolatus.*

Note.—The first recognised species of this genus—Hall's *Graptolithus ensiformis*—was regarded by its discoverer as belonging to *Retiolites* (Barrande) or an allied genus (Hall, 'Grapt. of Quebec Group,' p. 114). This opinion, which is in harmony with certain similarities in outward form and appearance, has naturally led to its being generally assigned to the family of the Retiolitidæ (Lapw., 'Geol. Mag.,' 1873, Table, p. 555, and others). Although it must be admitted that our

knowledge of the structure of the polypary in this genus is still very imperfect, such British examples as have come to hand lead us to infer that the alliances of the genus are rather with the Phyllograptidæ and Diplograptidæ, and we place it here provisionally in the latter family on account of its biserial character.

Trigonograptus ensiformis (Hall). Plate XXXV, figs. 1 *a—c*.

1865. *Retiolites ensiformis*, Hall, Grapt. of Quebec Group, Geol. Survey of Canada, dec. 2, p. 114, pl. xiv, figs. 1—5.
1890. *Trigonograptus ensiformis*, H. O. Nicholson, Geol. Mag., dec. 3, vol. vii, p. 340, figs. 1, 2.
1898. *Trigonograptus ensiformis*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 523, fig. 34.
1904. *Trigonograptus ensiformis*, Ruedemann, Grapt. New York, vol. i, p. 727, pl. xvii, figs. 1—9.

Polypary 3—5 cm. or more in length, with an average uniform width of about 5 cm. attained by rapid widening from proximal end, diminishing somewhat distally. Sicula doubtful. Thecæ eleven to nine in 10 mm., apparently inclined at about 50°, in contact throughout their length, their apertural edges usually forming collectively an unbroken line constituting the ventral margin of the polypary. Test thick, membranous, marked by growth-lines.

FIGS. 202 *a, b* and *c*.—*Trigonograptus ensiformis* (Hall).

a. Proximal end, showing sicula (?) and membranous structure. Enlargement of part of Pl. XXXV, fig. 1 *a*.
b. Distal thecæ, showing growth-lines. Enlargement of part of Pl. XXXV, fig. 1 *b*.
c. Distal thecæ of wide specimen. Roadside N. end of Doolough, Co. Mayo; Arenig. Coll. Muff and Carruthers.

Description.—The dimensions of the majority of our British specimens seem to fall a little short of those given by Hall, and examples of about 3 cm. in length are of most frequent occurrence. In other respects, however, our specimens agree well with the American ones.

In one specimen (Pl. XXXV, fig. 1 *a*) a membranous structure is seen projecting from the proximal extremity of the polypary. This may in part represent the sicula.

The thecæ present different appearances in different specimens. In some examples (Fig. 202 *a*) the walls of the thecæ are parallel and continuous from the ventral edge of the polypary to its central line; in others (202 *b*) the walls appear to be curved and there is an oblique ridge running down the centre of each theca. In one Irish specimen (202 *c*) the polypary appears at first sight to present a totally different aspect on the two sides of the central line. On the one side the thecæ resemble those of one of the four stipes of a *Phyllo-*

graptus when shown in profile view, but the edges of the aperture are straight or rounded instead of concave; on the other side the thecal apertures, or their impressions, are presented in scalariform view. These appearances might be accounted for if the polypary were composed of two stipes disposed at right angles to each other, somewhat like a *Phyllograptus* with only two of its adjacent stipes developed. Growth-lines appear occasionally on the thecæ, but there is no visible reticulation of the test, which in British specimens appears to be membranous and continuous.

Affinities.—*T. ensiformis* may be readily separated from its variety *lanceolatus* by its general shape.

Horizon and Localities.—Arenig, Upper Skiddaw Slates (Ellergill Beds).

Lake District: Mosedale Beck, near Troutbeck; Ellergill, near Millburn. *Ireland:* Roadside, N. end of Doolough, Co. Mayo. *S. Wales:* Pont-y-feni Quarry, 3 miles W. of St. Clears.

Associates, etc.—The associates of *T. ensiformis* in the Skiddaw Slates are unknown; but it has been found in Co. Mayo associated with *Loganog. Logani*, *Phyllog. angustifolius*, *Tetrag. quadribrachiatus*, and *Glossog. acanthus;* and by the officers of the Geological Survey in S. Wales with *Didymog. cfr. uniformis.*

Collections.—Nicholson, Geological Survey of England and Wales, Sedgwick Museum, Muff and Carruthers.

Var. **lanceolatus** (Nicholson). Plate XXXV, fig. 2.

1869. *Trigonograpsus lanceolatus*, Nicholson, Ann. Mag. Nat. Hist. [4], vol. iv, p. 232, pl. xi, fig. 6.

A variety of *Trigonog. ensiformis* is also found in the Skiddaw Slates and has been described by Nicholson. It differs chiefly from the typical species in the rapidity with which it widens in the proximal region, and in having a distinct zigzag septal groove or thickening. The only British specimen known to us shews no details as to the structure of the thecæ, but there are fourteen in 10 mm.

FIG. 203.—*Trigonograptus ensiformis*, var. *lanceolatus* (Nich.).

Distal part showing position of thecæ and zigzag septal groove; preserved as a cast. Enlargement of part of Pl. XXXV, fig. 2.

Horizon and Locality.—Upper Skiddaw Slates (Ellergill Beds).

Lake District: Ellergill, Millburn.

Associates, etc.—Unknown.

Collection.—British Museum (Natural History).

Family GLOSSOGRAPTIDÆ, *Lapworth.*

1873. *Glossograptidæ*, Lapworth, Geol. Mag., vol. x, table 1, p. 555.
1880. *Lasiograptidæ*, Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, p. 175.
1880. *Lasiograptidæ* or *Glossograptidæ*, Lapworth, Ann. Mag. Nat. Hist. [5], vol. vi, p. 188.

Biserial Graptoloidea with straight polyparies; test membranous, continuous, attenuated, more or less strengthened by lists, ribs, or filaments, which may, in whole or in part, constitute together a supporting net-like framework or skeleton. Thecæ of the general Diplograptid type, provided with spurs, spines, or other processes, which may be simple, branching, or connected to form an external lacework of marginal meshes.

A first and most characteristic feature of this family is afforded by *the invariable presence of external processes in the form of spurs, spines, or strong filaments.* Some of these agree in all essentials with those met with in the spine-bearing species of the Diplograptidæ (*Orthog. quadrimucronatus*, etc.), but others are very different, and in no other family of the Graptolites are these processes so distinctive or so varied in their form and peculiarities.

These extraneous processes in the Glossograptidæ are either medial or marginal in position; occurring either along (1) its central longitudinal line (*i. e.* that marked by the sutural groove in those Diplograptidæ which are provided with a septum) or (2) its ventral edges. As the terms mesial and marginal are pre-occupied, the two sets of processes are here classed as *septal* and *ventral*, these terms being employed merely as indicative of relative position.

The *septal processes*, when present, apparently arise at right angles to the axes of the thecæ, and form two ranks—one on the obverse and one on the reverse aspect. In both ranks they appear to be given off from the bases of alternate thecæ.

The *ventral processes* are either apertural or mesial in origin with respect to each theca, arising either from the angles of the apertural margin or from the upper angle of the excavation. In both cases they always appear to be paired.

Both septal and ventral processes may, within the limits of the family, take the form of (1) rigid blind spurs (Fig. 205 *e*), (2) more or less flexuous spines (Fig. 204), or (3) filamentous and fibrous processes, either simple, branching, or anastomosing (Fig. 213 *c*). When in the form of simple spurs or spines they significantly call to mind the proximal spines of the polypary in some of the Diplograptidæ, and, like those, occasionally support between them a membranous *pelta*, web, disc, or vesicle (Fig. 212 *b*). The branching processes are usually more fibrous in their nature and may support a much larger vesicle or pelta (Fig. 212 *a*).

The anastomosing processes are somewhat stout at their origin, becoming more filiform as they extend; and in several species they unite exteriorly with the corresponding processes above and below, and thus form in combination a more or less continuous external meshwork or lacework (*lacinia*) completely surrounding the theca-bearing portion of the polypary (Figs. 215 *a* and *e*).

A second characteristic of the Glossograptidæ which is intimately related to the first (compare Ruedemann, 'Grapt. New York,' Part 2, pp. 69—87) is afforded by *the distinct strengthening of the edges and angles of the polypary and thecæ, and the simultaneous attenuation of the intervening parts of the test.*

Within the limits of the family of the Diplograptidæ, as we have seen, there is an occasional tendency for the test to become somewhat thickened along certain definite lines. Thus, in *Orthog. quadrimucronatus* this thickening takes the form of a well-marked selvage, band, or flange, surrounding the edge of the aperture; while in *Amplexog. perexcavatus* not only is the apertural margin strengthened in this way, but also the ventral angles of the test around the excavation. But in the family of the Glossograptidæ this tendency to local thickening and strengthening becomes progressively developed and intensified. Not only may the apertural margins and ventral angles of the thecæ become strengthened in this way, but the strengthening may be continued along the outer line of contact of the thecal walls across the main body of the polypary, into and even along the median sutural line itself, the course of which may become marked by a continuous strengthening as definite as that marking the apertural margins. In all cases the local strengthening seems to be attained at the expense of the remainder of the test, which throughout the whole family of the Glossograptidæ is remarkably thin.

As this progressive differentiation is followed through the various genera and species, these narrow bands, selvages, or *lists* become more and more rounded and cord-like, and may eventually present the appearance—especially in examples preserved in pyrites—of wire-like fibres, coarse threads, or strong filaments, which are strikingly contrasted with the attenuated parts of the test which they support.

Within the limits of the related families of the Glossograptidæ and the Retiolitidæ occur forms showing almost every gradation between those in which only a few of the edges and angles are strengthened by lists or filaments, and those in which all the edges and angles are outlined in this manner.

These lists may be regarded from two distinct points of view—(*a*) as related to the elemental structure or theca, and (*b*) as related to the compound structure or polypary.

As respects their relation to the individual theca, they may outline the lip of its external opening (*apertural* or oral lists); the sides of that opening (*pleural*); the angles of the excavation (*mesial*); the lip of its internal budding orifice (*portal* or *aboral*); the outer line of contact with the theca immediately above or below

(*parietal*, Holm); and the line of contact along the sutural groove with the opposing thecæ of the alternating series (*dorsal* lists).

As regards the relations of the lists to the polypary considered as a whole, it naturally follows that when all the individual thecæ are outlined as above, the thecal lists constitute in combination a collective net-like or cage-like framework (*clathria*, from Lat. *clathri* or *clathra*), which forms, as it were, a skeleton of the complete polypary. Those thecal lists which then lie in the same general longitudinal line combine in appearance or reality into a single longitudinal list or *strand* (Wiman) running from end to end of the polypary, and the thecal lists which lie transverse to these form connecting *cross-bars* or *ledges* (Gurley).

Thus the dorsal lists combine into two longitudinal medial or *septal strands*, one (which is usually zig-zag) on the obverse, and one (which is usually straight) on the reverse aspect of the polypary. The pleural and other ventral lists combine into four longitudinal *ventral strands*, which are generally somewhat undulating and irregular. These upright strands are united in pairs by the cross-bars which are formed by the apertural and parietal lists (somewhat as the sides of a ladder are united by its rungs, or the sides of a lattice by its cross-bars).

The skeleton or clathria attains its most perfect development in the family of the Retiolitidæ, in the typical species of which—*Retiolites Geinitzianus*—its essential elements have been made known to us by the researches, descriptions, and figures of Tullberg, Törnquist, Holm, and Wiman (see Figs. 220 *d*—*f*).

The longitudinal strands enable us conventionally to regard the structural meshwork of the clathria as divisible into six *fields* (Wiman), *scalars*, or *lattices:* namely, two *ventral lattices*, of each of which the sides are the two upright ventral strands, and the cross-bars (which are normally horizontal) are usually the apertural lists of the thecæ; and four *parietal lattices*, of each of which the more or less upright sides are formed by one of the septal strands and one of the ventral strands lying on the same aspect, and the cross-bars (which are usually inclined) are the *parietal lists*. In addition to the cross-bars belonging to these six lattices, the clathria is sometimes provided with two sets of internal transverse cross-bars or *struts*, formed of the aboral lists.

Owing to the differences in the original shape of the polypary and thecæ, and the special parts of these which have been strengthened or differentiated as lists or filaments, there are great variations in the extent of development and in the details of the apparent skeleton as presented by the several species of Glossograptidæ and Retiolitidæ. Some of the so-called strands are often only such in appearance, being formed of different elements in different parts of their length; and the cross-bars of the apparent ventral lattice are not always the same in origin. The combined appearances presented in compressed specimens of the Glossograptidæ by (*a*) the clathria when partially developed, (*b*) the remainder of the polypary, and (*c*) the various external appendages, are always difficult of interpre-

tation. Not only do these appearances alter with every change in the amount or the direction of compression, but owing to the general tenuity of the test the upper and lower faces of the fossil as presented, are often shown in superposition in the same view.

As regards the general mode of development of the initial part of the polypary in the Glossograptidæ, it resembles in the main that of the Diplograptidæ.

As respects the systematic position of the Glossograptidæ, the general form of the polypary and the shape of the thecæ, both indicate a close relation to the Diplograptidæ, but the localisation of the thickening in the test resulting in the ultimate development of the skeletal frame-work is indicative of a most intimate relationship with the family of the Retiolitidæ, with which it was originally associated by Lapworth in 1873 ('Geol. Mag.,' vol. x, p. 555), to constitute the section Retioloidea.

Within the limits of the family of the Glossograptidæ, as at present understood, there are three divisions, typified respectively by the genera *Glossograptus*, *Lasiograptus*, and *Retiograptus* (*Clathrograptus*).

In the genera *Glossograptus* and *Retiograptus* the thecæ are of the type of those of *Orthograptus*: in the genus *Lasiograptus* they are usually of the type of those of *Amplexograptus*.

Genus **GLOSSOGRAPTUS**, *Emmons*.

1855. *Glossograptus*, Emmons, American Geology, vol. i, p. 108.

Polypary bilaterally symmetrical, truncato-elliptical in transverse section, provided with both apertural and septal processes. Apertural processes simple paired spines; septal processes in the form of stiff, blind spurs.

Thecæ of the general type of *Orthograptus*.

Test membranous, continuous, attenuated.

The truncato-elliptical transverse section of the polypary is evidenced by its lesser breadth when seen in the scalariform view, as compared with its breadth in the bi-profile view, and the still greater width when seen diagonally.

In the general mode of development of the proximal end the *Glossograpti* resemble the Diplograptidæ; the sicula and earlier thecæ, however, are relatively more spinose. The downward direction of the earlier spines, combined with the more or less horizontal growth of th. 1^1 and th. 1^2, give the proximal part of the polypary an appearance recalling that of the *Phyllograpti*.

In *Glossograptus* each theca has at least two apertural spines, though it not infrequently happens that, owing to the direction in which compression has been effected, only one is visible. These apertural spines may be stout or slender, but

they are always somewhat stiff in appearance, and are generally arcuate in form with the convexity upward. The bases of these spines are relatively broad, and have the appearance of being formed as prolongations of the combined thickened selvages of the whole of the denticle formed by the apertural and ventral edges of the theca. In general, these spines are about equal in length to the breadth of the polypary itself. In the proximal region they are directed downward but gradually alter their direction, first to a horizontal one in the middle of the polypary, and eventually to an ascending one towards its distal end.

In addition to the apertural spines, the polypary always appears to possess a series of septal spines. These originate from the mid-line of the polypary in a direction at right angles to the direction of the apertural spines, and are consequently best seen in the scalariform view, in which, owing to the direction of compression, the apertural spines are hidden, or so foreshortened as to be rarely visible. The septal spines occur both on the obverse and reverse aspect of the polypary, and in both cases apparently originate at or near the bases of alternate thecæ. As a rule they are larger and stiffer than the apertural spines, and usually take the form of blind spurs with broad bases.

Owing to the presence of these two sets of spines, the appearance of the polypary varies according to the direction of compression. In the bi-profile view the apertural spines alone are seen, and may appear to be single or paired. In the scalariform view the septal spines alone are usually visible, and the tips of the apertural spines are presented in addition only in rare cases. In the sub-scalariform view both sets of spines are visible in whole or in part, and the ventral margins of the polypary have then a most remarkably spinose appearance throughout.

The thickenings of the angles and edges of the test in this genus are mainly confined to the apertural and ventral edges of the thecæ and the bases of the septal spurs; but there is occasionally seen a well-marked longitudinal thickening bordering what appears to be the outer line of the septum on the two aspects, forming a pair of more or less continuous longitudinal ridges or strands (?) running parallel with the central line of the polypary.

Four species of *Glossograptus* and one variety have been recognised in the British Isles, viz.:

Glossog. cfr. *ciliatus.*
Glossog. Hincksii.
var. *fimbriatus.*
Glossog. armatus.
Glossog. acanthus.

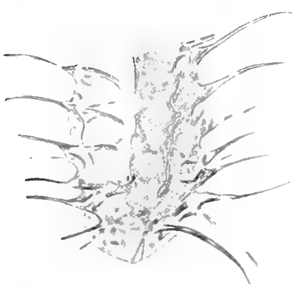
Glossograptus cfr. **ciliatus,** Emmons. Plate XXXIII, fig. 1.

1855. *Glossograptus ciliatus*, Emmons, American Geology, vol. i, p. 108, pl. i, fig. 25.
1908. *Glossograptus ciliatus*, Ruedemann (pars), Grapt. New York, pt. 2, p. 379, pl. xxvii, figs. 1—4.

Polypary broad with parallel margins, from 1—2 cm. or more in length, and with a maximum breadth of about 4 mm. Thecæ ten in 10 mm., with long and somewhat delicate spines; apertural margins approximately horizontal.

Description.—The species here described and figured is the only British one that appears to us to resemble Emmons' species, to which it is here doubtfully referred. All the specimens are small, and probably represent young forms; the one here figured shows the parallel margins, broad base, and relatively long and slender (ciliate) spines characteristic of the type specimens figured by Emmons. In our British examples it is impossible to distinguish the apertural from the septal spines.

Fig. 204.—*Glossograptus* cfr. *ciliatus*, Emmons.



Proximal end, showing sicula. Enlargement of part of Pl. XXXIII, fig. 1 *a*.

The sicula is partially visible for a length of 8 mm., but its apertural spines are not preserved.

Affinities.—*Glossog.* cfr. *ciliatus* resembles in some respects *Glossog. acanthus*, but differs in having sub-parallel margins and longer and more delicate spines. From *Glossog. Hincksii* it appears to be distinguished by the broader base of the polypary, the more distant thecæ, and the characters of the spines.

Horizon and Locality.—Llandeilo. *Wales:* Ty-Obry.

Associates, etc.—*Glossog.* cfr. *ciliatus* is found in the Llandeilo rocks of Ty-Obry associated with various Diplograptidæ.

Collection.—Sedgwick Museum.

Glossograptus Hincksii (Hopkinson). Plate XXXIII, figs. 2 *a*—*j*.

1872. *Diplograptus Hincksii*, Hopkinson, Geol. Mag., vol. ix, p. 507, pl. xii, fig. 9.
1876. *Glossograptus Hincksii*, Lapworth, Cat. West. Scott. Foss., pl. ii, fig. 57.
1877. *Glossograptus Hincksii*, Lapworth, Proc. Belfast Nat. Field Club, p. 134, pl. vi, fig. 24.

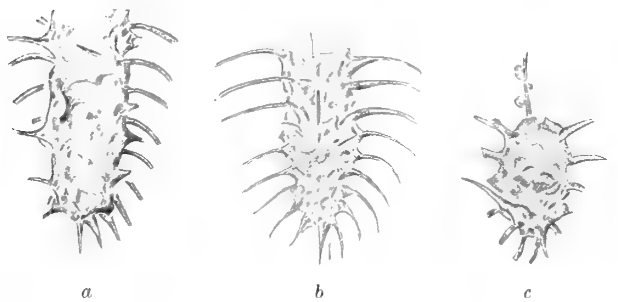
Polypary 2—4 cm. in length with rounded base, widening rapidly to a maximum breadth of 3 mm., which is then maintained. Sicula obscure, apertural spines of sicula and of all proximal thecæ directed more or less

vertically downward. Virgular tube long and conspicuous. Thecæ sixteen to ten in 10 mm., overlapping about one half their length; apertural margins straight, or but slightly everted; apertural spines strong, arcuate, nearly as long as width of polypary; septal spines straight, spur-like, ascending.

Description.—The polypary of *Glossog. Hincksii* varies very much in size; some specimens may be as much as 4 cm. in length, but the majority are smaller and do not exceed 2·5 cm. These smaller forms rarely reach the maximum breadth, but all show the subparallel character of the ventral margins.

The characters of the proximal end are obscure; the sicula seems to be at least 1 mm. in length and to have a stout virgella and also an additional apertural spine on the other side of its aperture, while the apertural portion lies wholly outside the polypary. The position on the sicula where th. 1^1 originates has not been determined, but the growth of th. 1^1 is mainly in a horizontal direction, the thecæ bending upward eventually close to the aperture; the same is also the case with th. 1^2. Spines are given off from these thecæ both from the aperture and also from the point (mesial) at which change of growth takes place, and they are directed mainly downward. The second pair of thecæ, th. 2^1 and th. 2^2, and all succeeding thecæ grow upward and outward in the usual Diplograptid manner. The apertural spines become gradually more and more ascending in position, until in the distal part of the polypary they are directed upward. These spines are always strong, and are arcuate in form; in the proximal region they do not exceed 1 mm. in length, but in the median region of the polypary, where they are practically horizontal, they may be nearly 3 mm. long. The septal spines are straighter and spur-like, and appear to have an ascending direction.

Figs. 205 *a*—*c*.—*Glossograptus Hincksii* (Hopk.).



a. Proximal end, showing both thecal and septal spines. Enlargement of part of Pl. XXXIII, fig. 2 *f*.
b. Proximal end, showing long curved apertural spines. Enlargement of part of Pl. XXXIII, fig. 2 *a*.
c. Young specimen, probably referable to this form, with conspicuous septal spine. Dobb's Linn, Glenkiln Shales. Coll. Lapworth.

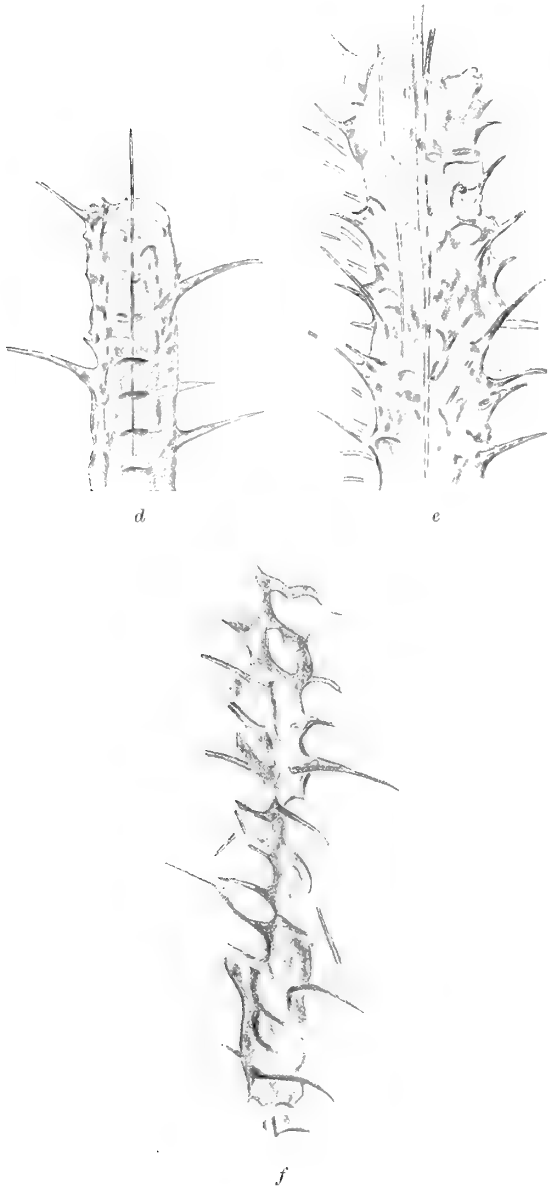
The thickenings of the apertural margins (apertural lists) and of the ventral margins are occasionally well shown, and certain specimens show the thickening of the outer edge of the septum almost individualised as a continuous band or thread (Fig. 205 *e*).

The virgula is very conspicuous and is generally prolonged for a distance greater than that of the length of the polypary. In the Glenkiln Shales of Wanlock Water the virgula appears as a definite wire-like thread on the surface of the rock, but at Birnock Water and Hartfell, etc., it seems to be

enclosed in a membrane which gives an appearance of undue breadth (Pl. XXXIII, figs. 2 *i*, *j*).

Affinities.—The affinities of this, the most abundant of all the British forms of the *Glossograpti*, are decidedly with the American form referred to *Glossog. ciliatus* (Emmons) by Ruedemann ('Graptolites of New York,' pt. 2, pl. xxvi, figs. 1—5; pl. xxvii, figs. 1—4), of which it may prove to be merely a variety, or at all events a vicarious representative. The British form may, however, be distinguished by the narrower and more rounded form of the base, the more closely-set thecæ (especially in the proximal region), and the stouter character of the spines. From var. *fimbriatus* it differs in the larger and more robust form of the polypary; and from *Glossog. acanthus* it may readily be separated by the shape of the polypary and the character of the spines.

Figs. 205 *d*—*f*.—*Glossograptus Hincksii* (Hopk.).



d. Distal end, scalariform view, showing apertures of thecæ and strong septal spurs.
e. Distal end, subscalariform view, showing both apertural and septal spines and also one septal strand clearly distinct from virgular tube. Enlargement of part of Pl. XXXIII, fig. 2 *i*.
f. Specimen with test almost removed, showing lists and spinous processes. Hartfell Spa, Hartfell Shales (zone of *Climacog. Wilsoni?*). Coll. Geol. Survey of Scotland.

Horizon and Localities.—Llandeilo and Bala (Glenkiln and Lower Hartfell Shales).

South Scotland: Wanlock Water, Wanlock Head; Birnock Water; Trowdale Glen, Castle Douglas; Hartfell Spa; Dobb's Linn, etc. *Ireland:* Coalpit Bay, Donaghadee; Ballygrot, Co. Down.

Associates, etc.—*Glossog. Hincksii* is an abundant fossil in one bed in the Glenkiln Shales at Wanlock Water, Wanlock Head. It is associated at this horizon with *Nemag. gracilis* and *Didymog. superstes*, etc. It is also fairly abundant near the base of the Hartfell Shales (zone of *Climacog. Wilsoni*) at Hartfell Spa, and Dobb's Linn in the Moffat country, where it is

commonly associated with *Climacog. Wilsoni*, *Dicranog. Nicholsoni*, and *Climacog. Scharenbergi*.

Collections.—Geological Survey of Scotland, Sedgwick Museum, Swanston, Lapworth, and the Authors.

Var. **fimbriatus** (Hopkinson). Plate XXXIII, figs. 3 *a—d*.

1872. *Diplograptus fimbriatus*, Hopkinson, Geol. Mag., vol. ix, p. 506, pl. xii, fig. 8.
1898. *Glossograptus fimbriatus*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 521, fig. 32.

In addition to the large form just described there occasionally occurs in the same beds, or more rarely at a lower horizon, a similar but much smaller form which Hopkinson separated as a distinct species, but which we consider is best regarded merely as a variety of *Glossog. Hincksii.* It differs from the typical form not only in point of size but in being somewhat less robust and in having somewhat shorter and more delicate spines.

Fig. 206.—*Glossograptus Hincksii*, var. *fimbriatus* (Hopk.).

Complete specimen. Brownhill Burn, near junction with Water of Deugh, Kirkcudbright; Glenkiln Shales. Coll. Geol. Survey of Scotland.

Horizon and Localities.—Arenig, Upper Skiddaw Slates (Ellergill Beds); Llandeilo, Glenkiln Shales.

S. Scotland: Wanlock Water, Wanlock Head; Wandel Water, near Abington; Rein Gill, Wandel Water; Brownhill Burn, near junction with Water of Deugh; Minnoch Water.

Wales: Tiddyndicwm, Penmorfa. *Lake District:* Ellergill; Mosedale Beck, near Troutbeck; Barf. *Ireland:* Doolough, Co. Mayo.

Associates, etc.—Var. *fimbriatus* occurs in the Upper Skiddaw Slates, but its associates are only definitely known at Ellergill, where it occurs in the beds with *Didymog. bifidus*, etc. In S. Scotland it occurs in the Glenkiln Shales in fair abundance associated with *Dicellog. sextans*, and var. *exilis*, *Dicranog. rectus*, *Nemag. gracilis*, *Didymog. superstes*, *Amplexog. perexcavatus*, etc.

Collections.—Geological Survey of Scotland, Sedgwick Museum, British Museum (Natural History), Muff and Carruthers.

Glossograptus armatus, Nicholson. Plate XXXIII, figs. 5 *a—e*.

1869. *Glossograptus armatus*, Nicholson, Ann. Mag. Nat. Hist. [4], vol. iv, p. 234, pl. xi, fig. 8.
1898. *Glossograptus armatus*, Elles, Quart. Journ. Geol. Soc., vol. liv, p. 523, fig. 33.
1898. *Glossograptus* cfr. *Hincksii*, Elles, loc. cit., vol. liv, p. 522.

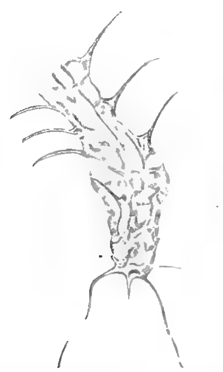
Polypary small, about 1 cm. in length, and having an average uniform breadth of rather less than 2 mm. Virgella distinct, basal spines very long and

flexed. Thecæ nine in 10 mm., overlap very slight; apertural margins slightly everted; apertural spines somewhat slender and rigid; septal spines straight and stiff.

Description.—The polypary is characteristically small, and the spines are more distant from each other than in other species belonging to the genus. These spines are slender and somewhat rigid, and are commonly about 2 mm. in length, though they may be as much as 3 mm. The septal spines are somewhat similar in size and form, but are straighter and more rigid.

The sicula is not visible, though its position is indicated by a conspicuous virgella, which has a length of about 1 mm. Th. 1^1 and th. 1^2 are, in addition to their apertural spines, provided with very long curved mesial spines, about 4 mm. in length, which originate at the point where the thecæ change their direction of growth from horizontal to upward and outward, and these curve down so that their extremities are nearly parallel to the virgella. These spines seem to be a prolongation of the thickening of the earlier parts of the lower walls of th. 1^1 and th. 1^2, and show as almost continuous lists across the polypary.

FIG. 207.—*Glossograptus armatus*, Nich.



Proximal end, showing two sets of spines on th. 1^1 and th. 1^2. Enlargement of part of Pl. XXXIII, fig. 5 *d*.

The type specimens of *Glossog. armatus*, which came from Thornship Beck in the Lake District, are very indifferently preserved, especially as regards the proximal end, and the present description has been drawn up from much better preserved examples from Morrach Bay, South Scotland, which are believed to be referable to Nicholson's species.

Affinities, etc.—*Glossog. armatus* presents a certain resemblance to small examples of *G. Hincksii*, but it differs from it in the size of the polypary, the more distant thecæ, and the long basal spines. From *G. Hincksii* var. *fimbriatus* it differs in the number of thecæ and the presence of the long curved spines at the base.

Horizon and Localities.—Llandeilo, Glenkiln Shales; and Upper Skiddaw Slates (Ellergill Beds).

S. Scotland: Back Burn, Crawick Water; Polmorlach Burn, Dumfries; Stream $1\frac{1}{2}$ miles E. of Manwhill Head, Waters of Ken; Kirriereoch Burn, and Kinniemore Burn, Water of Minnoch. *Lake District:* Thornship Beck.

Associates.—In the Upper Skiddaw Slates *Glossog. armatus* occurs in the Ellergill Beds associated with *Glyptog. dentatus.* In the Glenkiln Shales it occurs with *Didymog. superstes*, *Nemag. pertenuis*, and *Dicranog. celticus.* It is a rare fossil.

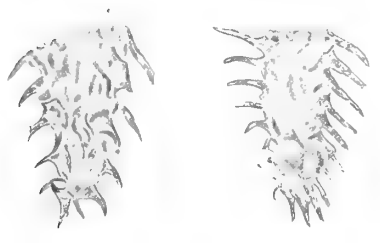
Collections.—Geological Survey of Scotland, Sedgwick Museum, British Museum (Natural History).

Glossograptus acanthus, sp. nov. Plate XXXIII, figs. 4 *a—c*.

Polypary sub-fusiform, having a length of about 2·5 cm. or more, and widening quickly from 1·5 mm. to a maximum breadth of 4 mm., then diminishing distally. Sicula only observed in its apertural region. Thecæ ten in 10 mm.; apertural margins distinctly everted, with robust, rigid, slightly curved apertural spines nearly equal in length to breadth of polypary; septal spines ? robust, stiff.

Description.—The polypary of *G. acanthus* is characterised by its breadth, sub-fusiform outline, and robust spines. These spines appear much broader than in any other British species, the denticle being distinctly elongated and its thickened margins merging insensibly into the base of the spine itself. In the proximal region of the polypary they usually extend mainly in a downward direction, but they gradually become more or less horizontal, and in the distal region they have a somewhat ascending direction. In this form we rarely see more than one of the two apertural spines belonging to each theca. The septal spines are not known with certainty.

FIGS. 208 *a* and *b*.—*Glossograptus acanthus*, sp. nov.



a *b*

a. Proximal end, showing disposition of thecal spines. Enlargement of part of Pl. XXXIII, fig. 4 *a*.
b. Proximal end, thecæ somewhat distorted. Enlargement of part of Pl. XXXIII, fig. 4 *c*.

The sicula, which is only seen in its apertural region, appears to extend free beyond the end of the polypary. It is provided with two stout spines.

The sub-fusiform shape of the polypary and the disposition of the spines give to this species a more Phyllograptid appearance than that of any of its British congeners.

Affinities.—*G. acanthus* somewhat resembles *G. echinatus*, Ruedemann, but differs in its more fusiform shape and in the disposition and more robust nature of its spines.

Horizon and Localities.—Arenig (zones of *Didymog. bifidus* and *D. extensus*). Skiddaw Slates (Ellergill beds).

Lake District: Thornship Beck. *S. Wales:* Llanvirn Quarry, near St. David's. *N. Wales:* Nant-yr-Orlof, Arenig. *Ireland:* Sruffaunduff, half a mile W. of summit of Bencraff, Connemara; W. end of Rossroe Peninsula, between the Killaries; Roadside, N. end of Doolough, Co. Mayo.

Associates, etc.—*Glossog. acanthus* occurs in Wales and the Lake District associated with *Didymog. bifidus*, and in Ireland it has been found by Messrs. Muff and Carruthers on a somewhat lower horizon (zone of *Didymog. extensus*), associated with *Tetrag. quadribrachiatus*, *T. Amii*, *Hallog. mucronatus* var. *inutilis*, *Phyllograptus*, etc.

Collections.—Sedgwick Museum, Muff and Carruthers, Fearnsides.

Table of Specific Characters of the Genus GLOSSOGRAPTUS.

	GLOSSOGRAPTUS.				
	G. cfr. *ciliatus.*	*G. Hincksii.*		*G. armatus.*	*G. acanthus.*
			var. *fimbriatus.*		
Character of polypary	Broad, parallel-sided	Fairly long, widening rapidly	Smaller than typical form	Small	Subfusiform, widening quickly
Maximum width	4 mm.	3 mm.	2 mm.	2 mm., uniform	4 mm.
Character of proximal end	Broad	Narrow	—	With long flexed spines	—
Characters of thecæ—					
(1) No. in 10 mm.	10	16—10	—	9	10
(2) Apertural margin	Horizontal	Horizontal or slightly everted	—	Slightly everted	Everted
(3) Ornamentation—					
(*a*) Apertural spines	Long and delicate	Strong arcuate	—	Slender, rigid	Robust, rigid, slightly curved
(*b*) Septal spines	?	Straight, spur-like	—	Straight, stiff	? Robust, stiff

Genus **RETIOGRAPTUS**, *Hall.*

1865. *Retiograptus*, Hall, Grapt. of Quebec Group, Geol. Survey Canada, dec. 2, p. 115.
1873. *Clathrograptus*, Lapworth, Geol. Mag., vol. x, p. 559.

Polypary bilaterally symmetrical, truncato-elliptical or sub-hexagonal in transverse section; septal, apertural and parietal lists usually present, and tending to form a more or less complete supporting skeletal framework or clathria. Ventral and septal processes unknown.

Thecæ of the general *Orthograptus* type.

Test membranous, continuous, greatly attenuated.

Only two species of this genus are known in Britain. The first was originally described by Lapworth as *Clathrograptus cuneiformis.* The researches of Ruedemann, however, make it evident that this form is certainly congeneric (if not identical with) the original *Retiograptus Geinitzianus* of Hall, which name has the priority, though it is a singularly unfortunate one. The second is the form described by Lapworth as *Idiograptus aculeatus*, which appears to be a very close ally of Hall's *Retiograptus eucharis.*

The affinities of *Retiograptus* are somewhat doubtful; it is here regarded as being more or less intermediate between *Glossograptus* and *Retiolites.* It agrees with *Glossograptus* in the general continuity of its test and the shape of the thecæ; but the clathria is much more strongly differentiated as such. It approaches

Retiolites in this last respect, but the intervening test is not reticulate as in that genus.

Retiograptus Geinitzianus, Hall. Plate XXXIV, figs. 7 *a—d*.

1859. *Reteograptus Geinitzianus*, Hall, Pal. New York, p. 518.
1860. *Reteograptus Barrandi*, Hall, New York State Cab. Nat. Hist., 13th Ann. Report, p. 61, figure.
1873. *Clathrograptus cuneiformis*, Lapworth, Geol. Mag., vol. x, p. 559.
1876. *Clathrograptus cuneiformis*, Lapworth, Cat. West. Scott. Foss., pl. iii, fig. 63.
1908. *Retiograptus Geinitzianus*, Ruedemann, Grapt. of New York, part 2, p. 463, pl. xxix, figs. 5, 6; pl. xxxi, figs. 9—17.

Polypary small, with sub-parallel margins, not exceeding 1·5 cm. in length and widening rapidly to a maximum breadth of 2 mm., which is then maintained. Test continuous, greatly attenuated, but locally strengthened by lists into a more or less complete clathria with sub-quadrangular meshes. Sicula visible in its apertural region only. Thecæ fourteen in 10 mm.

FIGS. 209 *a*, *b*, and *c*.—*Retiograptus Geinitzianus*, Hall.

a. Complete specimen, in relief, showing sicula, both parietal lattices, and part of one of the ventral ones. Enlargement of part of Pl. XXXIV, fig. 7 *a*.
b. Compressed specimen showing clathria, enlargement of part of Pl. XXXIV, fig. 7 *c*.
c. Specimen showing the two ventral lattices torn apart and twisted. Birnock Water, Glenkiln Shales. Coll. Lapworth.

Description.—The most striking characteristic of this form is afforded by the notable development of the thickening of the salient edges and angles of the polypary and thecæ, and the simultaneous attenuation of the intervening parts of the test. The result is that the fossil generally presents itself upon the surface of the rock in the form of a clathria of coarse strand-like threads and cross-bars, in the panels of which occur patches of the intervening attenuated membrane of the test, which also irregularly borders or shades into the strands and cross-bars themselves.

The septal strands are usually well defined, and one (if not both) is distinctly zigzag. The lists of the parietal lattice are often conspicuous and generally edged by a membrane; they have an ascending direction, and are gently curved, arising at a wide angle from the septal strand, flowing gracefully into the apparent ventral strand, the panels thus circumscribed being pentagonal or sub-elliptical

in shape. In examples preserved in partial relief (Fig. 209 *a*) the nearer composite ventral strands form the outer visible edges of the fossil, and appear to be formed in part of the thickened ventral edges of the successive thecæ and in part of their apertural lists; these last when compressed give the profile a spinose appearance. Sometimes a part or the whole of one of the ventral lattices is shown in this view (Fig. 209 *a*). The ventral lattice itself sometimes becomes wholly detached (Fig. 209 *c*) and its undulating limiting strands and the cross-bars are well exhibited.

When the fossil is in low relief (Fig. 209 *a*) the continuous attenuated test is usually found preserved in the earlier parts of the polypary: when greatly compressed little or nothing remains except the cage-like clathria (Fig. 209 *b*).

The transverse section of the polypary appears to have been subquadrangular or truncato-elliptical. The thecæ were somewhat of the form of those of *Orthograptus*, but broad towards their bases and narrowing in the direction of the aperture, which is strongly listed. The thecæ were distinctly inclined; the proximal or ventral wall of each was somewhat sigmoid, swelling out below and bent inwards above. There are occasional traces of a short apertural mucro, but in this species no evidences of the presence of septal spurs or processes have been detected.

The sicula is only visible in its apertural portion, which extends outside the polypary, and is covered by a continuous membranous test.

Affinities.—*Retiog. Geinitzianus* is very distinct in its outward features from any of the other British species of the Glossograptidæ. It most nearly resembles *R. aculeatus*, which is, however, a less compact and more straggling form.

Horizon and Localities.—Llandeilo, Glenkiln Shales.

S. Scotland: Birnock Water; Head of Wandel Burn, Birnock Water; Berrybush Burn; Benan Burn, R. Stinchar. *C. Wales:* Gwern-y-fed-fach, near Builth.

Associates, etc.—*Retiog. Geinitzianus* is a rare fossil in the Glenkiln Shales and other beds on the same horizon, but when found is commonly associated with *Dicellog. sextans*, *Didymog. superstes*, *Nemag. pertenuis*, *N. gracilis*, *Climacog. antiquus*, etc.

Collections.—Lapworth, Geological Survey of Scotland, and the Authors.

Retiograptus aculeatus (Lapworth).

1880. *Idiograptus aculeatus*, Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, p. 168, pl. v, figs. 23 *a*—*f*.

Such specimens of this form as we have in our possession are in their present state too poorly preserved to enable us to make out the necessary details for figuring and description, and reference may be made to Lapworth's original diagnosis and illustrations (*loc. cit. supra*).

Affinities.—Retiog. aculeatus (which Lapworth made the type of his genus *Idiograptus*) resembles *Retiog. Geinitzianus* in its small size, in the tenuity of the periderm and the development of the clathria. It is, however, altogether a more lax form and the apertural spines are more conspicuous; in one example, indeed, some of these appear to be long and flexed and suggestive of those of the *Lasiograpti*.

So far as can be gathered from the published figures and descriptions, this form appears to be closely allied to Hall's American species—*Retiograptus eucharis* ('Grapt. of Quebec Group,' dec. 2, 1865, pl. xiv, fig. 9)—made classic by the researches and observations of Ruedemann ('Grapt. of New York,' pt. 2, p. 397 *et seq.*, pl. xxvi, fig. 19; pl. xxvii, figs. 11—13, etc.).

Horizon and Localities.—Middle Bala, Middle Ardmillan Series, and Hartfell Shales.

S. Scotland: Shalloch Mill, Girvan; Dobb's Linn; Syart Law.

Associates, etc.—*Retiog. aculeatus* is common in a single bed in the Middle Ardmillan Series of Shalloch Mill, Girvan; it is rare in the Hartfell Shales of Dobb's Linn and Syart Law.

Collection.—Lapworth.

Genus **LASIOGRAPTUS**, *Lapworth* (extended).

1873. *Lasiograptus*, Lapworth, Geol. Mag., vol. x, p. 559.

Polypary bilaterally symmetrical, quadrangular to concavo-convex in transverse section, with sub-parallel margins. Septal and ventral lists conspicuous, appendages in the form of spines, or of fibrous processes which may (1) remain free, (2) may be connected by a web, or (3) may anastomose to form a more or less complete marginal lace-work.

Thecæ of the general type of those of *Amplexograptus*.

The tendency to special localisation of thickening in the periderm, which first becomes conspicuous in the *Glossograpti*, and is intensified in the *Retiograpti*, is developed to a remarkably high degree in the *Lasiograpti*. The edges and angles of the thecæ become differentiated almost into a continuous cord, filament, or fibre, that shows through the test along the thickened selvages like a rib in an umbrella or the piping of a hem.

Broadly speaking, it may be said that it is this listed and fibrated structure which is continued into, and constitutes the main element of, the extraneous processes generally, which are more varied in form in the *Lasiograpti* than in any other known group of biserial Graptolites.

When they take the form of spines they are, unlike those in the *Glossograpti*, always more or less flexed, and often become distinctly fibrous. These spines appear to be always ventral in origin, septal spines or spurs like those in *Glossograptus* being unknown in the *Lasiograpti*. But in place of the septal spurs, however, there occur in two sub-genera of this group remarkable septal processes (*scopulæ*, Hopkinson and Lapworth, 1875), each consisting of a pair of fairly stout stem-like fibres, which give off or break up into branches and fibrillæ, supporting a membranous film that usually shades away at its extremity into the surrounding rock. These scopulæ appear to be identical with the "reproductive processes" of Hall (*Gr.* [*Orthog.*] *Whitfieldi*). Sometimes the scopulæ present the appearance of a double membrane, web, or sac, outlined along its lower and upper edges by a strong fibre originating as an unbranched filiform process. Sometimes these septal processes with their sac-like membranes are seen to arise directly from the naked central strand well beyond the distal extremity of the polypary (Fig. 212 *b*).

The ventral processes in the *Lasiograpti* are typically mesial in origin, though in some forms there may apparently be apertural processes in addition. In all cases they seem to be paired, and in many cases to be formed, as it were, of the naked prolongations of the fibrous thickening of the angles of the thecal walls etc., the thickening extending continuously backwards to the central line or to one of the septal strands of the polypary. When these ventral processes take the form of spines they may be free (*Hallog. mucronatus*), or each pair may support between them a fan-like or tongue-like membrane or *pelta* (*Hallog.* var. *bimucronatus*). When the ventral processes take the form of filaments or fibres, these are in some cases free and almost straight (*Thysanog. retusus*). Generally, however, these filamentous processes are bent into a graceful declining curve (usually convex outwards) and eventually unite with the corresponding filaments of the processes immediately below, giving origin in this way to a complete marginal lace-work of fine filaments, which extends continuously along the whole ventral side of the polypary. This ventral lace-work varies much in its details; sometimes it is fairly simple, and is formed throughout of two pairs of sub-parallel filaments united by cross-threads (*Thysanog. Harknessi*); sometimes the filaments break up again and again to form a finer lace-work (*Neurog. fibratus*); and in one sub-genus (*Nymphograptus*) the lace-work is still more complex, being formed of long, sub-parallel strands united by fine cross-fibres, and apparently forming a peripheral lace-work surrounding the whole of the polypary. For this marginal lace-work we suggest the neutral term *lacinia*, leaving it to future research to determine how much of it lies wholly extraneous to the ventral edges of the thecæ themselves.

Within the limits of the genus *Lasiograptus* as at present understood there are but few known species; but these are so distinct in their external characteristics

that they appear to be naturally separable into four groups or sub-genera, distinguished partly by the form of the thecæ and partly by the nature of the extraneous processes.

Group I.—*Lasiograpti* in which the thecæ approximate in form to those of *Glossograptus;* ventral spines and processes flexed, free or connected by a web; septal processes when present in the form of scopulæ.

= *Hallograptus*, Carruthers.

Type *Hallograptus mucronatus.*

var. *inutilis.*

var. *bimucronatus.*

sub-var. *nobilis.*

Group II.—*Lasiograpti* in which the thecæ are of the typical *Amplexograptus* form; ventral processes typically united to form a complete ventral lacinia.

= *Thysanograptus* nov. (*Lasiograptus*, Lapworth).

Type *Thysanog. Harknessi.*

var. *costatus.*

retusus.

Group III.—*Lasiograpti* in which the thecæ resemble those of *Hallograptus;* ventral and septal processes united to form a peripheral lacinia.

= *Nymphograptus*, Lapworth, MS.

Type *Nymphog. velatus.*

Group IV.—*Lasiograpti* in which the thecæ appear to be of the type of *Hallograptus;* polypary strongly clathriate; ventral processes united to form a ventral lacinia; septal processes, when present, in the form of scopulæ.

= *Neurograptus*, Lapworth.

Type *Neurograptus fibratus.*

margaritatus.

Sub-genus **Hallograptus**, *Carruthers, MS.*

1877. *Hallograptus*, Lapworth, Grapt. Co. Down, Proc. Belf. Nat. Field Club, p. 134.

The name *Hallograptus* was originally suggested by Carruthers as the title for a genus to include the forms *Diplog. mucronatus* and *Diplog. bimucronatus.* The name was proposed in honour of Professor James Hall, who was the first to figure the scopulæ or "reproductive sacs" which are commonly associated with these forms, and was first published by Lapworth in 1877.

We adopt this name as that of the first group or sub-genus of the *Lasiograpti*, and include under it one species, two varieties, and one sub-variety.

Lasiograptus (Hallograptus) mucronatus (Hall). Plate XXXIII, figs. 6 *a—e*.

1843. *Graptolithus mucronatus*, Hall, Pal. New York, vol. i, p. 268, pl. lxxiii, figs. 1 *a—d*.

1877. *Diplograptus* (*Lasiograptus*) *mucronatus*, Lapworth, Proc. Belfast Nat. Field Club, Grapt. Co. Down, pl. vi, fig. 22.

1908. *Lasiograptus mucronatus*, Ruedemann, Grapt. New York, pt. 2, p. 479, pl. xxix, figs. 9—11; pl. xxx, figs. 1—5; pl. xxxi, figs. 1—3.

Polypary lax, having a length of 3—5 cm. and a breadth of 3 mm. exclusive of spines. Virgella conspicuous. Thecæ twelve to eight in 10 mm., having a length of 2·5 mm. and overlapping about one half their length; excavation prolonged almost up to the apertural margin, which is rostrate; ventral processes apparently apertural or sub-apertural in origin, long, slender, flexed, and paired.

Description.—The generally lax form of the polypary is a characteristic feature of this species. It is fairly wide, measuring 1·2 mm. at its origin and increasing at first rapidly and then more gradually up to a width of 3 mm., which is thereafter constant.

FIGS. 210 *a* and *b*.—*Hallograptus mucronatus* (Hall).

a *b*

a. Proximal end, showing paired thecal spines. Enlargement of part of Pl. XXXIII, fig. 6 *d*.
b. Distal thecæ, showing thickened angles of ventral excavation prolonged into spines. Cairn Ryan, Glenkiln Shales. Coll. Sedgwick Museum.

The sicula has not been observed, but its position is indicated by the virgella, which, though short and slender, is usually conspicuous, and has a length of ·5 mm. Th. 1^1 is occasionally seen to give off, in addition to the apertural spine, a mesial spine at the angle where upward growth commences. Th. 1^2 grows obliquely across the sicula and possesses two corresponding spines.

All the thecæ have rostrate apertural margins when compressed, and each is always provided with a long, slender, flexed spine, the base of which is broad, and appears to be formed by a gradual narrowing of the whole denticle. Although only one spine is usually visible, two are occasionally shown, and there is little or no doubt that the spines were invariably paired. Owing to the slender and flexed nature of these thecal spines, their direction is very variable.

It is uncertain whether any examples of this form were provided with scopulæ, but judging from the number of thecæ in 10 mm. it is probable that the scopulate specimen figured on Pl. XXXIII, fig. 6 *e*, is referable to this form.

Affinities.—The characteristic features of *H. mucronatus* are the curiously loose appearance of the stipe, and the irregular direction of growth of the spines. It presents at first sight some resemblance to *Orthog. quadrimucronatus*, but the spines are more slender and more flexed than in that species, the whole polypary is altogether less rigid and the thecæ are different in form. From

its variety *bimucronatus* it differs chiefly in having more remote thecæ; the general plan of construction of the polypary is, however, much the same in both.

Horizon and Localities.—Llandeilo, Glenkiln Shales and equivalent horizons.

S. Scotland: Glenkiln Burn; Cairn Ryan; Belcraig, etc. *N. Wales:* Tiddyndicwm; Ty Obry.

Associates, etc.—*Hallog. mucronatus* is an abundant fossil at some localities where there are good exposures of Glenkiln Shales, but as is often the case with Graptolites from that horizon, the specimens are for the most part but poorly preserved. Its common associates are *Nemag. gracilis*, *Dicellog. sextans*, and *Orthog. Whitfieldi.*

Collections.—Sedgwick Museum, Lapworth, and the Authors.

Var. **inutilis** (Hall). Plate XXXIII, figs. 7 *a—e*.

1865. *Diplograptus inutilis*, Hall, Grapt. of Quebec Group, p. 111.

1904. *Diplograptus inutilis*, Ruedemann, Grapt. of New York, pt. 1, p. 721, pl. xvi, figs. 12—13.

The form described by Hall as *Diplograptus inutilis* occurs in the Arenig rocks at a few localities only in the British Isles. It possesses, however, so many characters in common with *Hallog. mucronatus* that we believe it should be regarded as a variety of that species.

Fig. 211.—*Hallograptus mucronatus*, var. *inutilis* (Hall).

Distal thecæ showing general form. Enlargement of part of Pl. XXXIII, fig. 7 *d*.

The polypary is characteristically small, not exceeding 1·5 cm. in length, and the thecæ are more closely set, numbering twelve in 10 mm., while the spines are shorter and stiffer than in the typical form.

Horizon and Localities.—Arenig, Skiddaw Slates (zones of *Didymog. extensus* and *D. bifidus*).

Ireland: Sruffaunduff, half a mile west of Bencraff, Connemara. *Lake District:* Outerside. *S. Wales:* Ditch, 100 yards S.E. Kilnpark Farm, Narbeth.

Associates, etc.—Var. *inutilis* appears to be as rare a fossil in the British Isles as it is in America. The specimens from which the above description was drawn up were found by Messrs. Muff and Carruthers in the black shales and cherts of Arenig age in the district round Killary Harbour. It occurs there associated with *Tetrag. Amii*, *T. quadribrachiatus*, *T. serra*, *Didymog. extensus*, and *Glossog. acanthus.* A single specimen was found in South Wales by the officers of H. M. Geological Survey at a higher horizon associated with *Didymog. artus* and *Amplexog. confertus*, and one specimen is known from the Skiddaw Slates.

Collections.—Geological Survey of England and Wales, Sedgwick Museum, Muff and Carruthers.

Var. **bimucronatus** (Nicholson). Plate XXXIII, figs. 8 *a—e*.

1869. *Diplograptus bimucronatus*, Nicholson. Ann. Mag. Nat. Hist. [4], p. 236, pl. xi, figs. 12 and 12[1].

1877. *Diplograptus (Hallograptus) bimucronatus*, Lapworth, Proc. Belfast Nat. Field Club, p. 134, pl. vi, fig. 23.

1908. *Lasiograptus bimucronatus*, Ruedemann, Grapt. New York, pt. 2, p. 481, pl. xxix, figs. 12—18; pl. xxx, figs. 6—8; pl. xxxi, fig. 4.

This well-known form was originally distinguished and described by Nicholson as a distinct species, under the title *Diplograptus bimucronatus*, but it presents so many features in common with the type form of *Hallog. mucronatus* that we consider it better to regard it as a variety only. It differs from *H. mucronatus* mainly in having its thecæ much more closely set (sixteen to twelve in 10 mm.), especially in the proximal part of the polypary. In this variety the paired nature of the spinous processes is often well shown, and they sometimes appear as if united by a membrane in the earlier part of their length.

Fig. 212 *a.* — *Hallograptus mucronatus*, var. *bimucronatus* (Nich.).

Specimen showing scopulæ and also the thecal apertures. Wanlock Head, Glenkiln Shales. Coll. Lapworth.

Fig. 212 *b.* — *Hallograptus mucronatus*, var. *bimucronatus* (Nich.).

Fragment showing lateral and extra-distal scopulæ. Wanlock Head, Glenkiln Shales. Coll. Lapworth.

The polypary varies very much in size; it sometimes attains a length of 5 cm. or more, but specimens with a length of about 3 cm. are of most frequent occurrence. It widens more rapidly than in the typical form, and there is a tendency in some examples for the polypary to narrow again somewhat in the direction of the distal end.

Occasional specimens, which almost certainly belong to this form but are preserved in scalariform view, show distinct scopulate processes arising from the septal strands and extending outwards for some distance beyond the thecal margin of the polypary. They are apparently arranged in pairs, and occur at distances answering to the position of alternate thecæ. As a general rule, each process seems to consist of two main fibrous stems about three times the length of the width of the polypary. These stems are irregularly curved and throw off at intervals minor branches or branchlets which support between them a membranous film, the outer edges of which die away insensibly into the surrounding rock.

Sometimes the scopulæ present rather the appearance of a bag or disc edged and supported by simple and continuous fibres. In some examples the membrane has disappeared, and all that remains are the supporting fibres. Examples of scopulæ-bearing forms are comparatively rare, and few are sufficiently well preserved to be figured. The scopulæ themselves are apparently identical with the "reproductive sacs" of Hall ('Canadian Org. Rem.,' dec. 2, 1865, pl. B, figs. 6—11).

Horizon and Localities.—Llandeilo, Glenkiln Shales.

S. Scotland: Glenkiln Burn; Polmorlach Burn, Kirkconnel; Water of Deugh, a few yards below the Moor; foot of Hawkwood Burn, Wandel Water; Glentewing Burn; Back Burn, Crawick Water; Gairy near head of Garryhorn Burn. *Wales:* Tiddyndicwm. *Ireland:* Belvoir, Co. Clare.

Associates, etc.—Var. *bimucronatus* is a fairly common fossil in certain beds of the Glenkiln Shales of S. Scotland, where it is associated with *Nemag. gracilis*, *Dicellog. sextans*, *Dicranog. rectus*, *Climacog. Scharenbergi*, *Cryptog. tricornis*, etc.

Collections.—Geological Survey of Scotland, Geological Survey of Ireland, Sedgwick Museum, Lapworth, and the Authors.

Var. **nobilis**, nov. Plate XXXIII, figs. 9 *a—d*.

A sub-variety of *Hallog.* var. *bimucronatus* is worthy of separate description. It is both longer and broader than var. *bimucronatus*, and widens so quickly that the breadth is a conspicuous feature, even in quite young specimens which have not attained their full length. In this form, which may be appropriately called var. *nobilis*, the length may reach 7 cm. or more, and the breadth is fully 5 mm. (exclusive of the spinous processes); the margins may be parallel for the greater part of their length, or there may be a slight diminution towards the distal extremity in some of the larger specimens.

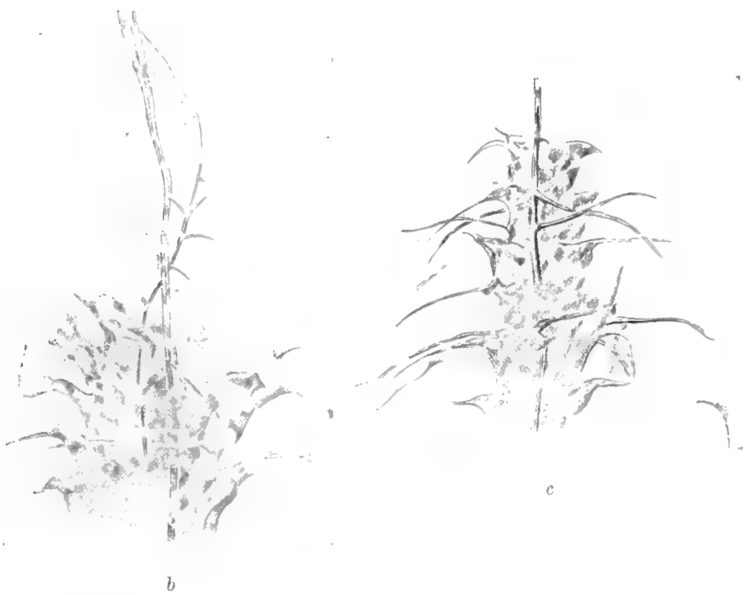
FIG. 213 *a*.—*Hallograptus bimucronatus*, var. *nobilis*, nov.

a

a. Proximal end, reverse aspect. Enlargement of part of Pl. XXXIII, fig. 9 *b*.

Owing to their large size and good state of preservation the examples of this variety allow us to interpret more perfectly the appearances presented by the spinous processes than in var. *bimucronatus* proper. The spines are longer and more flexed; their fibrous extremities hang down in graceful curves, sometimes reaching and passing beyond the level of the spines below. Some specimens show a septal strand distinct from the virgular tube, and short

FIGS. 213 *b* and *c*.—*Hallograptus bimucronatus*, var. *nobilis*, nov.



b. Distal end, showing straight virgular tube and curved septal strand throwing off processes. Enlargement of part of Pl. XXXIII, fig. 9 *a*.
c. Distal end, showing paired thecal spines, and also thickened septal strand giving off spurs. Enlargement of part of specimen on same slab as Fig. 213 *b*.

processes or, more rarely, scopulæ are given off from this strand well beyond the distal extremity of the polypary (Fig. 213 *b*). All the polyparies of this sub-variety preserved in a sub-scalariform or scalariform view show scopulæ, and at the same time parts of the thecal spines.

Horizon and Localities.—Glenkiln Shales.

S. Scotland: Burn W.N.W. of Low Glenling, 7 miles W. by S. of Wigtown; Pulharrow Burn, Carsphairn.

Collection.—Geological Survey of Scotland.

Sub-genus **Thysanograptus**, nov.

Those forms of *Lasiograpti* which possess thecæ of the typical *Amplexograptus* type and are provided with a marginal meshwork or lacinia of delicate connected filaments were alone originally included by Lapworth in his genus *Lasiograptus*. As this genus is here extended to embrace in addition other closely related species, we suggest the name *Thysanograptus* as a sub-generic title for the forms typified by *Lasiograptus Harknessi* and its variety *costatus*, to which the generic title was first applied.

Lasiograptus (Thysanograptus) Harknessi (Nicholson). Plate XXXIV, figs. 1 *a*—*d*.

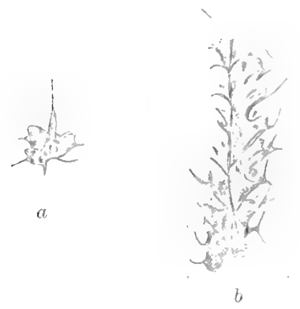
1867. *Diplograpsus Harknessi*, Nicholson, Geol. Mag., vol. iv, p. 262, pl. xi, fig. 6.

Polypary small, rarely exceeding 8 mm. in length, with an average uniform breadth of about 2 mm. exclusive of the external processes. Thecæ alternate, twelve in 10 mm., of the type of *Amplexograptus*. Lacinia ventral, delicate; occupying a space on both sides of the polypary equal to about half the

width of the central portion; apparently continuous and complete, but outer portions rarely preserved.

Description.—The polypary is very small, but relatively broad; it attains its maximum width of 2 mm. rapidly, and thereafter the margins are parallel. Specimens preserved in the scalariform view are generally much narrower than those presented in bi-profile view.

FIGS. 214 *a* and *b*.—*Thysanograptus Harknessi* (Nich.).



a. Young specimen showing complete sicula and three thecæ.
b. Complete specimen showing clathria partly developed. Reverse side of specimen figured Pl. XXXIV, fig. 1 *a*.

The sicula has a length of 1·5 mm., and in well preserved specimens three pairs of spines are commonly visible at the proximal end; one pair arising, as in *Glossograptus*, from each side of the aperture of the sicula, and one pair from the mesial angles of each of the thecæ—th. 1^1 and th. 1^2. Th. 1^1 grows at first horizontally, but soon bends upward in the direction of the aperture, while in th. 1^2 the growth is upward and outward throughout.

The external processes are delicate and thin. They are all ventral, and are apparently mesial in origin, arising from the thecal walls at the outer angle of the sigmoid bend. There are two belonging to each theca, and by the fusion of their anastomosing terminations form the marginal meshwork surrounding the ventral edges of the polypary. This lacinia is now usually very fragmentary, but its completeness in occasional examples shows that it must have been originally continuous.

Affinities.—*Thysanog. Harknessi* agrees very closely with its variety *costatus* in the general type of its thecæ, and Lapworth at one time held that the two forms were identical. But in *T. Harknessi* the polypary is always smaller than in var. *costatus*, the breadth is more uniform, and the thecæ are more remote. It is desirable, therefore, that the two forms be kept apart, and we retain *Lasiog. costatus* as a variety.

Horizon and Localities.—Bala, Hartfell Shales, Upper *Dicranograptus* Shales.

S. Scotland: Hartfell; above footpath Clodderoch Burn. *S. Wales:* Between Pemblewin and Stoneyford, Pembrokeshire.

Associates, etc.—*Thysanog. Harknessi* occurs in the Hartfell Shales in the zone of *Climacog. Wilsoni*, associated with *Climacog. bicornis* and *Orthog. truncatus* var. *intermedius*, and also in the zone of *Dicranog. Clingani*, associated with *Orthog. truncatus.*

Collections.—British Museum (Natural History), Geological Survey of Scotland, Sedgwick Museum, Lapworth, and the Authors.

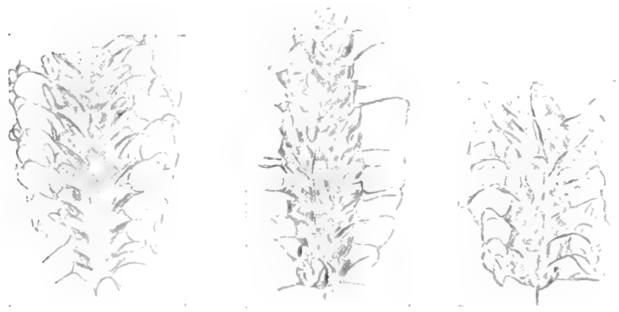
Var. **costatus** (Lapworth). Plate XXXIV, figs. 2 *a—d*.

1873. *Lasiograptus costatus*, Lapworth, Geol. Mag., vol. x, p. 559.

1877. *Lasiograptus costatus*, Lapworth, Grapt. Co. Down, Proc. Belfast Nat. Field Club, p. 135, pl. vi, fig. 26.

In this variety the polypary is larger than in the typical form, being from 1—1·5 cm. in length and widening steadily to a maximum breadth of 3 mm. The thecæ also are more closely set (sixteen to ten in 10 mm.). The ventral lacinia occupies a space equal to more than half the width of the central portion of the polypary, and is often preserved complete. The main ribs of the meshwork originate from the mesial angles of the thecæ; they have at first an ascending direction, but afterwards curve gracefully outward and downward, and finally descend almost vertically to anastomose with the extremity of the processes immediately

Figs. 215 *a—c.*—*Thysanograptus Harknessi*, var. *costatus* (Lapw.).



a *b* *c*

a. Proximal end, showing well-developed lacinia. Enlargement of part of Pl. XXXIV, fig. 2 *a*.
b. Complete specimen in semi-relief, showing sicula and fragmentary lacinia. Dobb's Linn, Hartfell Shales (zone of *Climacog. Wilsoni*). Coll. Lapworth.
c. Proximal end with test very attenuated; clathria and lacinia well shown. Dobb's Linn, Hartfell Shales. Coll. Lapworth.

Figs. 215 *d—g.*—*Thysanograptus Harknessi*, var. *costatus* (Lapworth).

d *e* *f* *g*

d. Complete specimen, with lacinia very imperfectly developed. Dobb's Linn, Hartfell Shales (zone of *Climacog. Wilsoni*). Coll. Lapworth.
e. Scalariform view, showing well-developed lacinia. Hartfell Spa, Hartfell Shales (zone of *Climacog. Wilsoni*). Coll. Lapworth.
f. Distal fragment, showing clathriate thickenings. Ibid.
g. Broad specimen, doubtfully referable to this form, with paired ventral processes united by flabellate membranes (peltæ). Dobb's Linn?, Hartfell Shales. Coll. Lapworth.

below. In many cases the outer portions of the processes break up into a minor meshwork which shows here and there traces of a connecting film. These processes are paired, for in certain specimens a second series can be seen, foreshortened and interior to the first series in position.

Horizon and Localities.—Llandeilo-Bala, Glenkiln Shales—Lower Hartfell (zone of *Climacog. Wilsoni*).

S. Scotland: Hartfell, Dobb's Linn; Rein Gill, Wandel Water; Cog Burn, a few yards above junction with Polroisk. *Shropshire:* Oakwood, Pontesford.

Associates, etc.—Var. *costatus* is not a common fossil in beds of Llandeilo age, but it is perhaps the commonest of the *Thysanograpti* present. It is fairly abundant in the Lower Hartfell Shales (zone of *Cl. Wilsoni*). It occurs in Shropshire associated with *Climacog. antiquus* and *Mesog. multidens;* in the Glenkiln Shales of S. Scotland with *Dicranog. rectus*, *Nemag. pertenuis*, and *Dicellog. sextans;* and in the Lower Hartfell Shales (zone of *Climacog. Wilsoni*) with the same fossil.

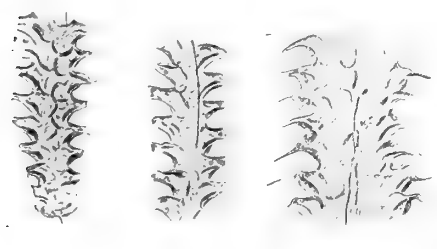
Collections.—Lapworth, Geological Survey of Scotland, Mr. P. Benson.

Lasiograptus (Thysanograptus) retusus (Lapworth). Plate XXXIV, figs. 3 *a—c*.

1880. *Lasiograptus retusus*, Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, p. 175, pl. v, figs. 24 *a—d*.

Polypary straight, about 2·5 cm. in length with average uniform breadth of about 2 mm. Thecæ attenuate, sixteen to fourteen in 10 mm.; excavations wide and deep, with thickened and fibre-like margins; spines, when preserved, short and stiff; marginal lacinia absent. Septal groove zig-zag and well marked.

Figs. 216*a—c*.—*Thysanograptus retusus* (Lapw.).



a *b* *c*

a. Proximal end, showing zig-zag septal groove and thickenings of ventral and apertural margins. Enlargement of part of Pl. XXXIV, fig. 3 *a*.
b. Distal thecæ, showing virgula. Ibid.
c. Distal thecæ of wider specimen, probably referable to this species, showing conspicuous thecal spines. Enlargement of part of specimen on same slab as Pl. XXXIV, fig. 3 *c*.

Description.—The polypary quickly attains its maximum width of 2 mm., and afterwards the margins are sub-parallel. The details of the structure of the proximal end are unknown.

The thecæ are markedly alternate in their arrangement, and closely resemble those of *Amplexog. perexcavatus*, but the apertural and ventral margins are occasionally thickened as with an inner wire-like fibre, and also the line of the zig-zag septal groove. In their form and mode of thickening the thecæ approach closely to those of *Thysanog. Harknessi* and its variety *costatus*, but though ventral spines are present a lacinia is apparently wanting.

This form was originally described from a single specimen from the Llandeilo Shales of the neighbourhood of Llandrindod (Pl. XXXIV, fig. 3 *a*). We figure also two other specimens which may belong to this species. The one (from Scotland) (Pl. XXXIV, fig. 3 *b*) has rather more distant thecæ, the other (from Cwm Brith Bank, Llandrindod Wells) (Pl. XXXIV, fig. 3 *c*) is wider (2·5—3 mm.) and has more closely-set thecæ; this may possibly show the obverse aspect. In the last example the spines are more conspicuous than in the type specimen.

Affinities.—*Th. retusus* differs from the other *Thysanograpti* to which it is allied in being a longer form, in having a distinct zig-zag septal groove, and in the absence of a lacinia.

Horizon and Localities.—Upper Arenig, Llandeilo.

Radnorshire: N. of Llandrindod Wells; N. of Cwm Brith Bank, nr. Llandrindod Wells. *S. Scotland:* Hartfell Spa ?.

Associates, etc.—*Th. retusus* occurs in the Llandeilo Rocks of Llandrindod associated with *Cryptog. tricornis*, var. *Schäferi*, and at a somewhat lower horizon associated with *Didymog. Murchisoni*, var. *geminus*.

Collections.—Lapworth and Miss C. Chamberlain, Birmingham.

Sub-genus **Nymphograptus**, *Lapworth, MS.*

As only one species of this sub-genus is at present known, its characters may in the main be regarded as typical for the sub-genus.

Lasiograptus (**Nymphograptus**) **velatus**, sp. nov. Plate XXXIV, figs. 4 *a* and *b*.

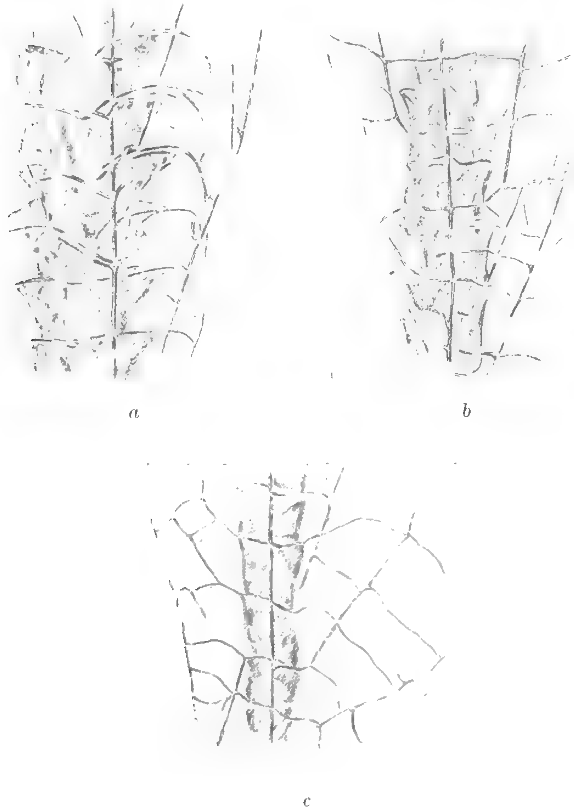
Polypary relatively large, at least 4 cm. in length, widening gradually from 1 mm. to a maximum breadth of 4 mm. Thecæ seven to six in 10 mm., of the general type of those of *Hallog. mucronatus*. Septal strands very strongly developed, extraneous processes filiform, united to form a broad and composite lacinia completely surrounding the polypary. Test continuous, fairly thin.

Description.—Of this fairy-like species only three examples are as yet known—one shown in the bi-profile view and two (on the same slab) in the scalariform view.

The most striking feature of this form is presented by its remarkably complicated lacinia. This is formed of a symmetrical arrangement of fine strands and delicate cross-filaments. So far as can be gathered from the appearances presented, this lacinia is composed of two main elements, namely, a first set of

curved ventral meshes apparently corresponding to the ventral meshwork in *Thysanograptus*, and a second set of straight and sub-parallel strands united with each other and to the first set by cross threads at fairly regular intervals.

FIG. 217 *a—c.—Nymphograptus velatus*, sp. nov.



a. Sub-scalariform view, showing form of thecæ. Enlargement of part of Pl. XXXIV, fig. 4 *b*.
b. Scalariform view, showing part of lacinia. Enlargement of part of Pl. XXXIV, fig. 4 *a* (left-hand specimen).
c. Ibid., showing lacinia in its most complete form. Enlargement of part of Pl. XXXIV, fig. 4 *a* (right-hand side specimen).

The main filaments belonging to the first set have the appearance of prolonging the apex of the apertural denticle, as in *Hallograptus*. Interiorly they are each distinctly carried backwards continuously until they unite with one of the septal strands of the clathria. Exteriorly they curve gracefully downwards and are connected with the corresponding filaments proceeding from the thecæ immediately below, as in *Thysanograptus;* there appears also to be a secondary reticulation on the outer side of the descending fibres as in that sub-genus.

The main filaments belonging to the second set appear somewhat stouter. They are straight and as a rule parallel, and have an outward and ascending direction answering more or less to the inclination of the ventral walls of the thecæ. They are of great length, some of them being prolonged to a distance corresponding to the extent of from 10 to 12 thecæ, and they are united by more delicate cross-threads, usually somewhat curved and set at distances approximately equal to the distance which separates the apertures of the thecæ.

Whether the straight strands of the external lattice-work originate directly from the septal strands of the clathria in the manner of the septal processes and scopulæ of *Hallograptus* and *Neurograptus* (see postea) is not certain; but in any case both the curved and the straight sets of filaments are united into a common extraneous lacinia, which apparently surrounds the whole polypary.

It is probable that the parallelism of the long straight strands is not original, but due in part to the direction in which compression has been effected, for some of those in the proximal region certainly widen the distance between them as they

proceed outward, in some cases to a breadth more than twice that between their points of origin.

Horizon and Localities.—Upper Hartfell Shales (zone of *Dicellog. anceps*).

S. Scotland: Ettrick Bridge End, Selkirk; Dobb's Linn (?).

Associates, etc.—The only three specimens of this species certainly known come from Ettrick Bridge End and belong to the Collection of the Geological Survey of Scotland, but fragments of a somewhat similar meshwork are not uncommon in the zone of *Dicellog. anceps* at Dobb's Linn, and may belong to the same form.

Collections.—Geological Survey of Scotland and the Authors.

Sub-genus **Neurograptus,** *Lapworth.*

1875. *Neurograptus*, Lapworth, Graptolites of the St. David's Area, Quart. Journ. Geol. Soc., vol. xxxi, p. 641.

Lasiograptus (Neurograptus) fibratus (Lapworth). Plate XXXIV, figs. 5 *a*—*c*.

1876. *Retiolites fibratus*, Lapworth, Cat. West. Scott. Foss., pl. iii, fig. 62.
1877. *Retiolites fibratus*, Lapworth, Grapt. Co. Down, Proc. Belf. Nat. Field Club, p. 136, pl. vi, fig. 28.

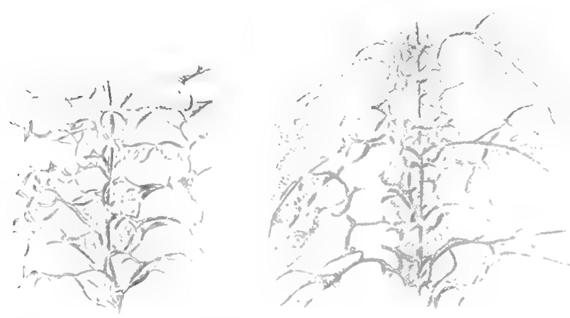
Polypary not exceeding 5 cm. in length, and having an average breadth of about 3 mm. (exclusive of the extraneous processes); margins sub-parallel for the greater part of their length; proximal end unknown. Thecæ ten in 10 mm., of the type of those of *Hallog. mucronatus.* Clathria well developed; ventral processes stout, fibrous, originating complete marginal lacinia; septal processes branching, scopulate. Test continuous, greatly attenuated.

Description.—The test in this species is remarkably thin, and the ribs and processes of the clathria relatively stout and stiff, so that at first sight the entire polypary and its appendages appear to be reduced to a network of interlacing threads, symmetrically arranged about two strong septal strands. The central theca-bearing portion of the polypary, as represented by its clathria, is narrow and inconspicuous, and must have been almost square in transverse section, for the width in the bi-profile and scalariform views is about the same.

There are two septal strands, the most conspicuous of which is practically straight, and the other undulating or zig-zag. In the bi-profile view, the main filaments of the ventral lacinia proceed from the denticle, at first directly outwards and almost horizontally, while the descending portion is less graceful and flowing than in most other forms of the *Lasiograpti.* Instead of the delicate minor

netting often shown in the exterior parts of the lacinia in other species, there is an irregular outer fringe having a somewhat ragged and spinous appearance.

Figs. 218 *a* and *b*.—*Neurograptus fibratus* (Lapw.).



a *b*

a. Thecæ in bi-profile view, showing lacinia and septal strands. Enlargement of part of Pl. XXXIV, fig. 5 *a*.
b. Scalariform view, showing straight septal strand and scopulæ. Enlargement of part of Pl. XXXIV, fig. 5 *c*.

In the scalariform view, the scopulate processes are well shown, each originating directly from one of the septal strands. They occur in pairs. The earlier or stem-like portion of each is at first horizontal, and is afterwards bent into a curve, the convex side being upwards. At a distance about equal to the diameter of the thecal portion of the polypary, it branches dichotomously, and the branches divide into branchlets in their turn; traces of an exceedingly thin membrane, which once probably connected the branches and branchlets, are occasionally discernible.

The thecæ are alternate in their arrangement and strikingly recall those of *Hallog. mucronatus*.

Affinities.—*N. fibratus* resembles closely *Neurog. margaritatus*, from which it differs chiefly in being a larger form, in having a stronger and more fibrous nature, a more attenuated test, and also scopulate septal processes.

Horizon and Localities.—Bala, Hartfell Shales.

S. Scotland: Hartfell; Dobb's Linn; etc. *Ireland:* Carnalea.

Associates, etc.—*Neurog. fibratus* occurs in the Lower Hartfell Shales in the zones of *Dicranog. Clingani* and *Pleurog. linearis*. It is found at the lower horizon associated with *Dicellog. Morrisi* and *Dicranog. ramosus*, and at the higher horizon with *Pleurog. linearis* and *Orthog. truncatus* var. *pauperatus*.

Collections.—Geological Survey of Scotland, Lapworth, Swanston, and the Authors.

Lasiograptus (Neurograptus) margaritatus (Lapworth). Plate XXXIV, figs. 6*a*—*c*.

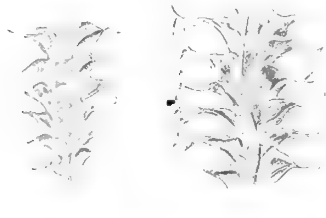
1876. *Lasiograptus margaritatus*, Lapworth, Cat. West. Scott. Foss., pl. ii, fig. 60.
1877. *Lasiograptus margaritatus*, Lapworth, Proc. Belf. Nat. Field Club, p. 135, pl. vi, fig. 25.

Polypary small and limp, about 1·5 cm. in length, with an average uniform breadth of 1·5 mm. (exclusive of the lacinia). Thecæ of the type of

Hallog. mucronatus, alternate, fourteen to twelve in 10 mm.; ventral processes slender, and united to form a continuous delicate lacinia.

Description.—The polypary is invariably short; it attains its maximum breadth almost at once, and maintains it to the distal extremity.

FIGS. 219 *a* and *b*.—*Neurograptus margaritatus* (Lapw.).



a. Proximal end. Dobb's Linn, Hartfell Shales (zone of *Dicranog. Clingani*). Coll. Lapworth.
b. Distal thecæ, showing lacinia. Enlargement of part of Pl. XXXIV, fig. 6 *a*.

The thecæ are of the same general form as those of *Hallog. mucronatus*, but are of smaller size and have a lesser amount of overlap. The ventral processes arising from the denticle are delicate and flexed, and curve broadly downward to meet those proceeding from the theca immediately below, the major interspaces thus formed being about the same length as the width of the central portion of the polypary. There is distinct evidence of a minor series of meshes along the outer edge of the lacinia. No scopulate processes have been observed in this form.

Affinities.—This species approaches *Neurog. fibratus* in the general characters of its thecæ and their appendages, but, as already pointed out, is a much smaller form; the test is thicker and the clathria not nearly so pronounced, while the scopulate processes appear to be wanting.

Horizon and Localities.—Lower Bala, Lower Hartfell (zone of *Dicranog. Clingani*).

S. Scotland: Dobb's Linn, Hartfell Spa, etc.

Associates, etc.—*N. margaritatus* occurs in great abundance in the Hartfell Shales associated with *Dicranog. ramosus* and *Leptograptus flaccidus* in the zone of *Dicranog. Clingani.*

Collections.—Lapworth, Geological Survey of Scotland, Swanston, and the Authors.

Family **RETIOLITIDÆ**, *Lapworth* (restricted).

1873. *Retiolitidæ*, Lapworth, Geol. Mag., vol. x, table i, p. 555.

Biserial Graptoloidea with straight polyparies. Thecæ of the general Diplograptid type. Test represented typically by a complete network of minute meshes supported upon a more or less well-defined skeleton or clathria of stronger filaments. Extraneous processes and lacinia absent or present.

The characteristic feature of all the forms belonging to this family *is the network of delicate chitinous tracery (reticula) which forms the outward visible covering of the walls of the thecæ*, and is attached to the skeleton and overlies the

whole of the polypary with the exception of the thecal apertures. The tracery of this reticula is sometimes filiform and subregular, but is often of irregular breadth and outline. Its minute meshes vary in form from circular to polygonal and quadrangular, but there is rarely any constancy in the direction of the component threads.

Broadly speaking, it may be inferred that this reticula represents a further development of the tendency to the general attenuation of the test and the local concentration of its material along more or less definite lines, resulting in a net-like structure. In the family of the Glossograptidæ this tendency has originated the clathria, and in the present family it is carried to an extreme, so that the whole of the visible test of the polypary has become reticulate.

It may be regarded as certain, however, that the visible network of the test in the Retiolitidæ (namely, the reticula and clathria combined) does not represent the entire thickness of the periderm. The researches of Richter, Wiman, Perner, Sollas, etc., go to show that the periderm is composed of at least three layers [the endochiton, the mesochiton, and the ectochiton], and that the network belongs to the middle layer, being overspread by the outer layer and underlain by the inner layer, both of which are membranous and continuous, but of such extreme tenuity that they are very rarely discernible.

The clathria also attains its fullest development in the family of the Retiolitidæ. That of the species *Retiolites* (*Gladiograptus*) *Geinitzianus* is especially complete, and is fully representative of the original form and structure of the polypary and thecæ. In many species, however, the clathria, although probably present as such, is remarkably inconspicuous, little of it being preserved beyond the septal strands and parts of the parietal lists.

A few forms afford evidence of the presence of definite *interthecal planes or floors*. These are usually membranous, but are so thin as to be visible only in rare cases.

The polypary itself varies much in form within the limits of the family; it may be long or short, narrow or broad. In transverse section it varies from concavo-convex to subquadrangular.

The characters of its proximal end are rarely exhibited, but occasionally there is evidence leading to the inference that the mode of development was similar to that in *Diplograptus*. In one British species (Fig. 226 *a*) a well-preserved sicula is shown, embraced as in *Diplograptus* by the earlier thecæ.

The thecæ in the Retiolitidæ present a considerable amount of variation in the different species. In some (Fig. 220 *c*) they are quadrangular tubes in contact throughout, so that four walls or sides are defined: namely, two exterior or lateral walls (one obverse and one reverse) and two interior walls (a floor or basement wall and a roof or covering wall). In others (Figs. 226 *b* and *c*) the terminal portion of the theca is free as in *Glyptograptus*, etc., and there appears to be a

distinct impression or excavation in the middle third of its ventral wall. In others, again, the actual forms of the thecæ are unknown, though occasionally their floors are visible (Figs. 221 *b* and *c*).

The apertural margins of the thecæ not only vary in form in the different species, but also in the matter of ornament. In some (Fig. 220 *c*) they are practically destitute of ornament, in others they are provided with ventral processes in the form of a pair of apertural spines (Figs. 226 *b* and *c*); in others, again, the ventral processes are combined into a marginal lacinia (Figs. 222 *a* and *c*). No evidences of the existence of septal processes have hitherto been detected in the British forms of the Retiolitidæ, nor of the possible representatives of these processes—the septal elevations and pores (?) shown in the continental examples of *Stomatograptus.*

The British species belonging to the family fall into three fairly well-marked groups, which are typified respectively by the species *Retiolites Geinitzianus*, Barr., *R. obesus*, Lapw., and *R. nassa*, Holm.

In the first of these groups the thecæ are quadrangular or subquadrangular in section, and practically destitute of ornament; in the second group the actual form of the thecæ is uncertain, but the polypary is provided with a ventral lacinia; in the third group the thecæ are flattened, steeply inclined, and occasionally spinose.

It may possibly be shown in the future that each of these groups is worthy of generic rank, but in the meantime we class them as subgenera only.

Group I.—*Retiolites* in which the thecæ are quadrangular or sub-quadrangular in section and practically devoid of ornament.

= *Gladiograptus*, Hopkinson and Lapworth.
Type *Gladiograptus Geinitzianus.*
var. *angustidens.*
G. perlatus.
var. *Daironi.*

Group II.—*Retiolites* in which the form of the thecæ is unknown but the polypary possesses a ventral lacinia.

= *Plegmatograptus*, nov.
Type *Plegmatograptus nebula.*
P. obesus.
var. *macilentus.*

Group III.—*Retiolites* in which the thecæ are steeply inclined, flattened, and occasionally spinose.

= *Gothograptus*, Frech.
Type *Gothograptus nassa.*
G. spinosus.

Sub-genus **Gladiograptus**, *Hopkinson and Lapworth.*

1850. *Gladiolites*, Barrande, Grapt. de Bohême, p. 68.
1875. *Gladiograptus*, Hopkinson and Lapworth, Quart. Journ. Geol. Soc., vol. xxxi, p. 659.

The name *Gladiograptus* was first suggested by Hopkinson and Lapworth (*loc. cit. supra*) as a synonym for Barrande's original name *Gladiolites* used by him in the diagnosis of his *Retiolites Geinitzianus;* and it is here restricted to those forms typified by that species. The sub-genus includes two British species and two varieties.

Retiolites (Gladiograptus) Geinitzianus, Barrande. Plate XXXIV, figs. 8 *a—d*.

1850. (*Gladiolites*) *Retiolites Geinitzianus*, Barrande, Grapt. de Bohême, p. 69, pl. iv, figs. 16—33.
1851. *Retiolites Geinitzianus*, Suess, Ueber Böhmische Grapt., p. 95, pl. vii, figs. 1 *d—e*.
1852. *Retiolites Geinitzianus*, Geinitz, Die Graptoliten, p. 52, pl. vi, figs. 1—8.
1868. *Retiolites Geinitzianus*, Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 530, pl. xix, figs. 19, 20.
1882. *Retiolites Geinitzianus*, Tullberg, Skånes Grapt., p. 41, pl. i, figs. 10—17.
1890. *Retiolites Geinitzianus*, Holm, Gotlands Grapt., Bihang. till k. Svensk. Vetensk.-Akad. Handl., vol. xvi, pt. 4, no. 7, p. 18, pl. ii, figs. 2—5.

Polypary sword-shape, robust, truncato-elliptical in transverse section, becoming concavo-convex as growth proceeds; 3—5 cm. or more in length, and widening steadily from a rounded base to a maximum breadth of 5 mm. Thecæ distinct, fourteen to nine in 10 mm., in contact throughout; outer walls finely reticulate, roof and floor membranous and continuous. Apertural margins normal, quadrangular, destitute of ornament. Clathria well developed, best shown in compressed specimens, the straight and zigzag strands being usually conspicuous, especially the former. Reticula fully developed, with sub-regular, rounded, or polygonal meshes.

Description.—The polypary in this species is sword-like in shape, and from specimens preserved in relief appears to have been truncato-elliptical in transverse section at the proximal extremity, becoming more concavo-convex distally, the central portion of the concave aspect being somewhat raised above the general level (Barrande).

The sicula has not been observed with certainty in British examples.

The thecæ are in contact throughout, and are, as a rule, mutually compressed into the form of hollow prisms, almost square in section, and from three to four times as long as wide.

The apertural margins are practically normal to the axis of the theca, but in compressed specimens have the appearance of being inclined. They vary in

appearance according to the amount and direction of compression; in some cases the ventral edge has the appearance of being straight and continuous, in others the compressed thecal apertures appear concave and strongly mucronate.

Figs. 220 *a*, *b*, and *c*.—*Gladiograptus Geinitzianus* (Barr.).

a *b* *c*

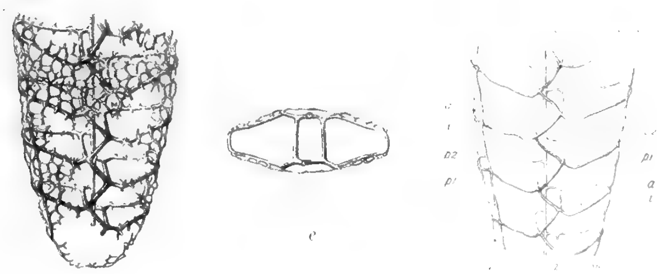
a. Distal fragment, showing straight and zigzag septal strands. Enlargement of part of specimen from Listice, Bohemia; Etage Ee. Coll. Sedgwick Museum.
b. Distal thecæ, obverse aspect, showing apertural denticles; also texture of reticula. Enlargement of part of Pl. XXXIV, fig. 8 *b*.
c. Sub-scalariform view, showing ventral lattice and parietal ledges. Enlargement of part of specimen from Řepora, Bohemia. Coll. Lapworth.

The substance of the reticula is thick compared with that of other British species in this family, and the tracery only occasionally appears to be actually fibrous or filamentous. Its interspaces are irregular in form and vary in number from three to four within the space limited by the distance between the floors of successive thecæ.

The clathria is often well shown in British examples of this species, but as few of them are preserved even in semi-relief the details are difficult of interpretation. Fortunately the elements of the entire clathria and their relations have been admirably worked out for European examples by Holm, Törnquist, and others, and reference may be made to their illustrative figures and descriptions and also to the terminology already summarised on pp. 305, 306.

The reticula covers all the panels formed by the outer walls of the thecæ, and is attached to the parietal lists, into which its threads appear to graduate. It also extends over the surface of the central parts of the polypary beyond the outwardly visible limits of the parietal lists, so that both in the obverse and reverse aspect of the polypary, when preserved in full or in half relief, there is a central longitudinal field destitute of other structure, and the septal strands and aboral lists are invisible (Fig. 220 *e*).

Figs. 220 *d*, *e*, and *f*.—*Gladiograptus Geinitzianus* (Barr.).



d *e* *f*

d. Restoration of proximal portion, showing clathria and parts of reticula. (*After Holm.*)
e. Transverse section, showing relations of clathria and reticula. (*After Holm.*)
f. Diagram of clathria only. *Strands:* *s*. Straight septal strand; *z*. zigzag septal strand; *v*. ventral strands. *Lists:* *a*. Apertural or oral; *i*. interior or aboral; *p*. parietal. Those elements marked (1) belong to the obverse aspect; those marked (2) to the reverse aspect.

Affinities, etc.—*Gladiog. Geinitzianus* does not appear to have any close allies in Britain with the exception of var. *angustidens*. It is distinguished from all other species by the form of the polypary and the characters of the clathria and reticula.

Horizon and Localities.—Gala-Tarannon and Lower Wenlock Shales, Riccarton Beds.

S. Scotland: Grieston Quarry, Innerleithen; Kirkcudbright Bay; Falbogue Bay, W. side Meikle Ross; Nether Stennis Water; Esk Reservoir, Pentland Hills. *N. Wales:* Conway River, W. side; Large Quarry Pen-y-glog, Dee Valley. *C. Wales:* Pencerrig, near Builth; Tarannon River; Afon Iaen, near Llanbrynmair; Plas bach, near Llanbrynmair, etc. *Lake District:* Pull Beck; Browgill; Swindale; Stockdale, etc.

Associates, etc.—*Gladiog. Geinitzianus* is a common fossil in the Lower Wenlock Shales, especially in the zone of *Cyrtog. Murchisoni*, where it occurs associated with *Cyrtog. Murchisoni*, *Monog. priodon, Monog. vomerinus*, and other forms. It is also found occasionally in the Tarannon Shales and their equivalents, occurring in the zones of *Monog. crenulatus*, *Monog. griestonensis*, and *Monog. crispus*, associated with the zone fossils.

Collections.—Geological Survey of Scotland, British Museum (Natural History), Sedgwick Museum, Lapworth, and the Authors, etc.

Var. **angustidens**, nov. Plate XXXIV, figs. 9 *a—c*.

In addition to the typical form of *Gladiog. Geinitzianus*, there occurs a closely allied form which differs conspicuously in being more uniformly narrow throughout its length; this appears to be worthy of varietal distinction.

In this variety, which commonly reaches a length of 5 cm. or more, the breadth never exceeds 3 mm.; it is attained gradually from the proximal end, and the margins are conspicuously parallel for the greater part of their extent.

Horizon and Locality.—Tarannon Shale, Browgill Beds.

Lake District: Swindale. *S. Scotland:* Falbogue Bay, W. side Meikle Ross, Kirkcudbright Bay.

Collections.—Sedgwick Museum (Coll. Fearnsides), Geological Survey of Scotland.

Retiolites (**Gladiograptus**) **perlatus,** Nicholson. Plate XXXIV, figs. 10 *a—f*.

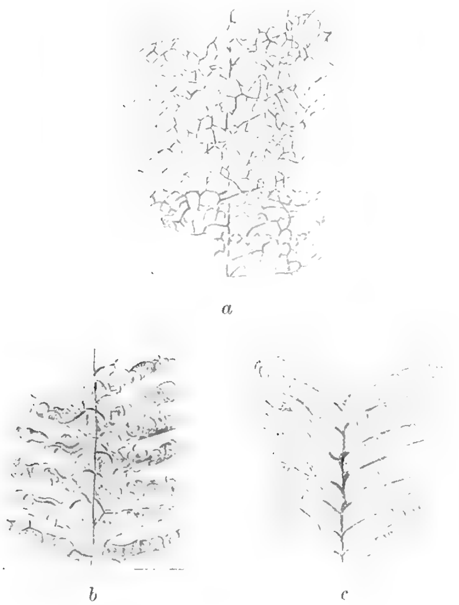
1868. *Retiolites perlatus*, Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 530, pl. xix, figs. 21, 22.
1890. *Retiolites cfr. perlatus*, Törnquist, Acta Univ. Lund., vol. xxvi, p. 11, pl. ii, fig. 26.

Polypary with a length of 2·5 cm., and an average uniform breadth of 5 mm.; this breadth is attained by rapid widening from the proximal end, and the margins are distally sub-parallel. Thecæ sixteen to twelve in 10 mm., indistinct; floors of thecæ membranous, sometimes marked by

lines of growth. Clathria very ill-defined. Reticula delicate and fibrous, with sub-rectangular meshes.

Description.—The outline of the complete polypary is generally very badly defined, the actual positions and courses of the ventral and apertural margins being only identifiable at intervals.

Figs. 221 *a*—*c*.—*Gladiograptus perlatus* (Nich.).



a. Distal fragment, showing texture of reticula. Enlargement of part of Pl. XXXIV, fig. 10 *c*.
b. Specimen showing the interthecal planes or floors. Enlargement of part of Pl. XXXIV, fig. 10 *b*.
c. Thecæ showing the floors marked by growth-lines; also the zigzag septal strand. Enlargement of part of Pl. XXXIV, fig. 10 *d*.

The elements of the clathria are as a rule almost indistinguishable, the straight septal strand and a few of the parietal bars being the only parts well shown. The reticula is very delicate and fibrous, and its meshes are usually sub-hexagonal. In some specimens (Pl. XXXIV, figs. 10 *b* and *d*), especially in the earlier portions of the polypary, the reticula has apparently disappeared altogether, and what appear to be the interthecal planes or floors of the thecæ are exposed, and these form parallel bands separated from each other by bare interspaces of about the same breadth. These floors are membranous, and are sometimes crossed by a series of fine growth-lines. This feature is very characteristic of most examples of the species.

Affinities.—*G. perlatus* somewhat resembles *G. Geinitzianus* in its structure, but its different shape, its much more delicate reticula and ill-defined clathria are well-marked distinctions.

Horizon and Locality.—Llandovery, Birkhill Shales (zone of *Monog. gregarius* to zone of *Monog. Sedgwickii*), Skelgill Beds.

Ireland: Coalpit Bay, Donaghadee, Co. Down. *S. Scotland:* Duffkinnell Burn, near Wamphray; Cramalt, Meggat Water; Dobb's Linn, etc. *Lake District:* Mosedale in Long Sleddale, Browgill.

Associates, etc.—*Gladiog. perlatus* is a rare fossil in the Llandovery Beds, in which it occurs in the zone of *Monog. gregarius* associated with *Monog. gregarius*, *Petalog. minor*, *Climacog. Törnquisti*, *Cl. Hughesi*, and other forms, and in the higher zone of *Monog. Sedgwickii*, with *M. Sedgwickii*, *M. convolutus*, *M. lobiferus*, *M. discretus*, *Orthog. bellulus*, and *Climacog. scalaris*.

Collections.—Belfast Museum of Natural History, British Museum (Natural History), and Lapworth.

Var. **Daironi**, Lapworth. Plate XXXIV, fig. 11.

1877. *Retiolites perlatus*, var. *Daironi*, Lapworth, Grapt. Co. Down, Proc. Belfast Nat. Field Club, p. 136, pl. vi, fig. 30.

In addition to the typical form *Gladiog. perlatus*, there occurs at a somewhat higher horizon at Craigmichan in S. Scotland a very much larger form designated by Lapworth as *R. perlatus*, var. *Daironi*. This form attains a length of at least 6 cm., and a final breadth of 1·1 cm. as the result of persistent widening from the proximal end. The thecæ are much larger and more distant than in the typical form, numbering twelve to eight in 10 mm. Only one specimen is known, and in this the reticula is hardly discernible, but the general outline of the polypary is well defined in the distal parts. The transverse growth-lines on the floors of the thecæ are locally distinct, especially towards the ventral margins, and recall those on the outer walls of the thecæ of *Petalograptus*. They appear to be occasionally fibrous and to be crossed by others in the form of a very fine ribbing.

Horizon and Locality.—Birkhill Shales (zone of *Rastrites maximus*).

S. Scotland: Craigmichan.

Collection.—Lapworth.

Sub-genus **Plegmatograptus**, nov.

The second group of the *Retiolites* includes two species and one variety in which the shape of the thecæ is unknown, but which appear to possess a ventral lacinia. As the latter is their most obvious feature we suggest for them the sub-generic name *Plegmatograptus*.

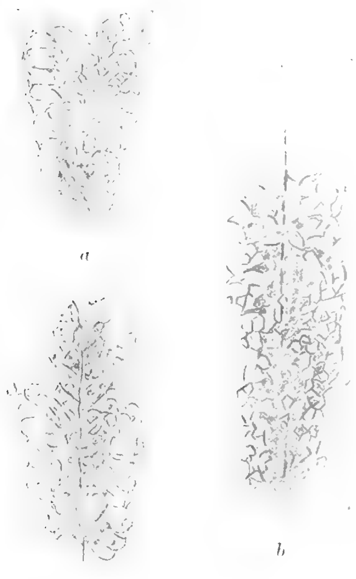
Retiolites (Plegmatograptus) nebula, sp. nov. Plate XXXIV, figs. 14 *a—d*.

Polypary very short and delicate, about 1 cm. in length, widening rapidly from 1 mm. at the proximal end to a maximum width of 2 mm. Virgella conspicuous, occasionally 3 mm. in length. Thecæ twelve in 10 mm.; their shape is indistinct, but the processes of their ventral margin give origin to a complete and somewhat complicated lacinia. The elements of the clathria cannot be made out, and the reticula, which is but rarely visible, is usually irregular and ill defined.

Description.—*P. nebula* is a very gregarious form, occurring as faint silvery cloud-like patches upon the surface of the rock. It presents very different

appearances according to the direction of compression. In the bi-profile view, the test of the polypary seems at first sight to be continuous and to have a nebulous and delicately membranous appearance, but when magnified it is seen to be very minutely reticulate; the component fibres are hardly distinguishable even under the lens in some examples, though in others the reticulation is distinctly shown. The ventral margins of the polypary are bordered by a continuous lacinia very similar to that of *Thysanograptus Harknessi*, var. *costatus*; but the outer threads anastomose more frequently, and occasionally appear as if covered by a faint membranous film.

Figs. 222 *a*, *b*, and *c*.—*Plegmatograptus nebula*, sp. nov.



a. Small specimen, as seen in bi-profile view, showing complete lacinia. N. end of Morrach Bay, Portpatrick; Hartfell Shales. Geol. Survey of Scotland.
b. Complete specimen as seen in scalariform view. Ibid.
c. Specimen in bi-profile view. Hartfell (?), Hartfell Shales. Coll. Lapworth.

In what appears to be the scalariform view, the whole surface occupied by the fossil is covered by a network of threads much coarser and more definite and with meshes larger than those of the fine reticula above mentioned. This network may be interpreted as representing both ventral laciniæ as shown superposed when the polypary has been compressed from the ventral aspect.

A virgella is occasionally visible, and in one specimen has a length of 3 mm. What appears to be the virgula is occasionally seen distally prolonged beyond the polypary.

The thecæ number twelve in 10 mm., but their shapes are very obscure.

We figure (Pl. XXXIV, fig. 14 *d*) a larger and wider form which we provisionally refer to this species. If more specimens are found this may eventually be separated off as a distinct variety.

Affinities.—The affinities of *P. nebula* appear to be on the one hand with *Thysanograptus Harknessi*, var. *costatus*, and on the other with *Plegmatog. obesus*, but its peculiar characters distinguish it readily from both.

Horizon and Localities.—Hartfell Shales (zone of *Dicranog. Clingani*).

S. Scotland: Dobb's Linn; Hartfell; N. end Morrach Bay, Portpatrick; Auchenvey Burn, near Ford Corsock; Burn at Gordonstown, half mile E.N.E. of Dalry; Wood of Cree, Newton Stewart; Clodderoch Burn, above footpath.

Associates, etc.—*Plegmatog. nebula* is a very common *Retiolite* in the Lower Hartfell Shales of some localities in S. Scotland, especially in the zone of *Dicranog. Clingani*, where it occurs associated with *Dicellog. Morrisi*, *D. Forchammeri*, *Orthog. calcaratus*, var. *vulgatus*, and *Lasiog. margaritatus*.

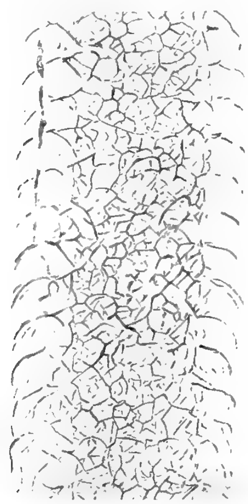
Collections.—Geological Survey of Scotland, Lapworth, and the Authors.

Retiolites (Plegmatograptus) obesus (Lapworth). Plate XXXIV, figs. 12 *a—c*.

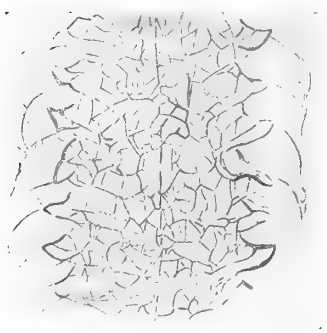
1876. *Retiolites perlatus*, Lapworth, Cat. West. Scott. Foss., pl. iii, fig. 61.
1877. *Retiolites perlatus*, var. *obesus*, Lapworth, Grapt. Co. Down, Proc. Belf. Nat. Field Club, p. 137, pl. vi, fig. 29.
1890. *Retiolites obesus*, Törnquist, Acta Univ. Lund., vol. xxvi, p. 10, pl. ii, figs. 24, 25.

Polypary 2—3 cm. in length, and relatively broad; having an average uniform breadth of about 8 mm. attained by rapid expansion in the proximal region. Thecæ with indistinct outlines, twelve to nine in 10 mm.; apertural margins concave, undulate; outer margin formed of a ventral braid apparently composed of paired inosculating fibres. Elements of clathria rarely showing; reticula filamentous with sub-hexagonal meshes.

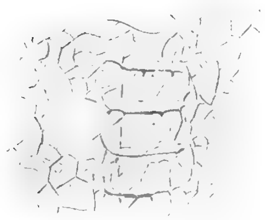
FIGS. 223 *a, b,* and *c.*—*Plegmatograptus obesus* (Lapw.).



a



b



c

a. Part of specimen showing ventral lacinia and texture of reticula. Elwand water, near Melrose; Gala Group. Coll. Lapworth.
b. Bi-profile view. Enlargement of part of Pl. XXXIV, fig. 12 *a*.
c. Scalariform view. Enlargement of part of Pl. XXXIV, fig. 12 *c*.

Description.—The polypary is somewhat small, but relatively very broad; the initial width does not exceed 1·5 mm., but increase takes place so rapidly that the maximum width is quickly attained, and the margins are then parallel for the remainder of their extent.

What appear to be the denticles of the thecæ are occasionally well defined and thickened; they appear to be either concave or undulate. The ventral margin of the fossil is bordered by a broad meshwork of curved threads which form a complete marginal braiding. The main fibres of the meshes appear to arise from the angles of the apertural margins and are paired. With the exception of its straight septal strand the clathria is ill-defined. The reticula, however, is usually well preserved, and is composed of irregular and somewhat wide sub-hexagonal meshes of fine thread-like fibres.

Affinities.—*P. obesus* can readily be distinguished from *Plegmatog. nebula* by the more robust character of the polypary, and the elegant and characteristic shape of the regular ventral meshes.

Horizon and Localities.—Gala-Tarannon.

S. Scotland: Elwand Water, near Melrose;

Meigle Hill, Gala; Mount Benger Burn. *C. Wales:* Gelli-dywyll, near Llanbryn-mair.

Collections.—Lapworth and the Authors.

Var. cfr. **macilentus** (Törnquist). Plate XXXIV, figs. 13 *a* and *b*.

1887. cfr. *Retiolites macilentus*, Törnquist, Geol. Fören. Förhandl., vol. ix, p. 491, fig. 3.

There occurs in the Browgill Beds of the Lake District a *Retiolites* closely allied to *Plegmatog. obesus*, which may be compared with *R. macilentus* of Törnquist, and is here regarded as a variety of *P. obesus.* It differs from the typical form chiefly in the character of the network, which shows very wide and regularly arranged hexagonal meshes throughout.

Fig. 224.—*Plegmatograptus obesus*, var. *macilentus* (Tornq.).

Distal fragment showing wide meshes. Enlargement of part of Pl. XXXIV, fig. 13 *a*.

Horizon and Locality.—Gala-Tarannon, Browgill Beds.

Lake District: Swindale Beck, Knock.

Associates, etc.—Var. cfr. *macilentus* is a rare fossil in Beds of Gala-Tarannon age, but has been found associated with *Monog. Marri*, *M. continens*, and *Ret.* (*Gladiog.*) *Geinitzianus*, etc.

Collections.—Marr, Sedgwick Museum (Coll. Nicholson and Fearnsides).

Sub-genus **Gothograptus**, *Frech.*

1897. *Gothograptus*, Frech, Lethea Geognostica Palæozoica, p. 670.

The title employed for this sub-genus was proposed by Frech to include Holm's species of *Retiolites, R. nassa.* The chief characteristic is afforded by the form of the thecæ. In addition to *R. nassa* the group includes *Ret.* (*Gothog.*) *spinosus.*

Retiolites (Gothograptus) nassa (Holm). Plate XXXIV, figs. 15 *a—d*.

1890. *Retiolites nassa*, Holm, Gotlands Graptoliter, Bihang till k. Svenska. Vet.-Akad. Handl., vol. xvi, pt. iv, no. 7, p. 25, pl. ii, figs. 12—14.

1897. *Gothograptus nassa*, Frech, Lethea Geognostica Palæozoica, p. 670.

1900. *Retiolites* (*Gothograptus*) *nassa*, Wood, Quart. Journ. Geol. Soc., vol. lvi, p. 486, pl. xxv, fig. 30, and text-fig. 27.

Polypary compact, small and narrow, not exceeding 1·3 cm. in length, with an average uniform breadth of about 1 mm. Sicula obscure, virgella long and conspicuous. Thecæ fifteen in 10 mm., approaching those of *Glyptograptus* or *Amplexograptus* in form, with small overlap; apertural margins slightly oblique, thickened and membranous. Clathria not well differentiated; reticula often conspicuous, meshes extremely minute, usually regular.

Description.—The polypary is always of small size and very narrow, not exceeding 1 mm. at its widest and tapering proximally. A prominent proximal structure corresponding to Wiman's "initial canal" (which may be the reticulate covering of the sicula), is often visible, projecting somewhat beyond the proximal end of the polypary after the manner of the sicula of *Climacog. Wilsoni* and other Diplograptidæ. The virgella is conspicuous and in one specimen has a length of fully 2 mm.

FIG. 225.—*Gothograptus nassa* (Holm).

Complete specimen, showing thecæ and apertural "lappets." Enlargement of Pl. XXXIV, fig. 15 *a*.

The thecæ in this species are considered by Holm and other authors to be of the *Climacograptus* type, but as the free edges of the thecæ are inclined rather than vertical, and the apertural margins slightly oblique, they are in form more suggestive of those of *Glyptograptus* or *Amplexograptus.* The thickening of the apertural margin is continued, as in the Swedish examples, in the form of a membranous tongue or "*lappet*" (Wiman). With the exception of the ventral lattice, none of the ordinary lattices of the clathria are well defined, and the strands and cross-bars are hardly separable from the threads of the reticula, which is here and there crossed subregularly by stronger fibres than usual.

Affinities.—*G. nassa* differs conspicuously in size and form from all other *Retiolites* except *Gothog. spinosus*, from which, however, it can readily be distinguished by the absence of apertural spines and by the finer meshes of the reticula.

Horizon and Localities.—Lower Ludlow Shales (zone of *Monog. vulgaris*).

Shropshire: Near Worthen, S. side of Long Mountain; Elton Lane, near Ludlow. *N. Wales*: Cefn-Gwyn, one mile E. of Eglwys Bach, E. side of Conway Valley.

Associates, etc.—*Gothog. nassa* is a rare fossil in Britain; a few specimens only have been found at the localities noted above; in every case it occurs associated with *Monog. vulgaris* and *M. dubius.*

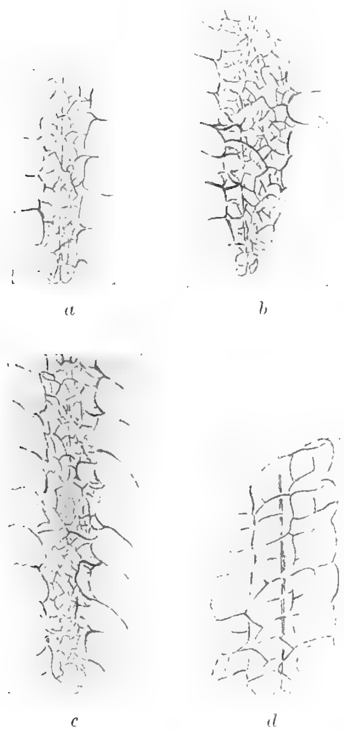
Collection.—The Authors.

Retiolites (Gothograptus) spinosus (Wood). Plate XXXIV, figs. 16 *a—c*.

1900. *Retiolites spinosus*, Wood, Quart. Journ. Geol. Soc., vol. lvi, p. 485, pl. xxv, figs. 29 A and B, and text-fig. 26 *a* and *b*.

Polypary small, not exceeding 2 cm. in length, and widening rapidly to a maximum breadth of about 1·8 mm. (exclusive of apertural spines) which is then maintained. Sicula small, ·5 mm. in length. Thecæ eleven to ten in 10 mm., free for greater portion of their length; apertural margins undulate and provided with long curved spines. Clathria fairly well defined, reticula somewhat coarse and irregular.

Figs. 226 *a—d*.—*Retiolites (Gothograptus) spinosus* (Wood).



a. Proximal end, showing sicula. Specimen on same slab as Pl. XXXIV, fig. 16 *b*.
b. Complete specimen, showing sicula and virgula, and paired apertural spines. Figured, 'Quart. Journ. Geol. Soc.,' vol. lvi, pl. xxv, fig. 29 B. Coll. Elles.
c. Sub-scalariform view, showing ventral lattice. Enlargement of part of Pl. XXXIV, fig. 16 *a*.
d. Specimen showing clathria. Vicarage Road, Builth; Lower Ludlow Shales. Coll. Wood.

Description.—The polypary has an initial breadth of about ·9 mm. which increases fairly rapidly up to 1·8 mm., which width is then maintained, so that distally the margins are sub-parallel.

What appears to be the sicula is occasionally visible just within the base of the reticula and has a membranous test. It has a length of ·5 mm., and a well-marked virgula proceeds from its apex in the normal manner. This is seen to be continuous throughout the polypary and is occasionally prolonged beyond its distal extremity.

In specimens in which the reticula has disappeared (Fig. 226 *d*), the clathria is well defined. The ventral lattice, the limiting strands of which are undulating, shows each alternate païr of cross-bars to be connected by a median vertical fibre, the interspaces between these apparently marking the apertures of the thecæ (compare Wiman). There are indications of two septal strands, one straight and the other zig-zag, but the parietal lattices are not well differentiated. The fibration of the reticula is irregular, showing comparatively wide meshes of very fine filaments.

The apertural spines of the thecæ are paired, but as a rule only one spine is visible. These spines always remain quite free, they are nearly as long as the width of the polypary, and typically curve downward, as in *Hallog. mucronatus* var. *bimucronatus*.

Specific Characters of Forms belonging to the Genus Retiolites.

	GROUP I = *Gladiograptus.*			
	G. Geinitzianus.	var. *angustidens.*	*G. perlatus.*	var. *Daironi.*
Character of polypary . .	Sword-shape, robust	Uniformly narrower than typical form	Widening rapidly from proximal end	Very much larger and coarser than typical form
Reticula	Texture thick, with sub-regular rounded, or polygonal meshes	—	Delicate and fibrous, with subrectangular meshes	?
Clathria	Well developed	—	Very ill defined	?
Maximum width . . .	5 mm.	3 mm.	5 mm.	1·1 cm.
No. of thecæ in 10 mm. . .	14—9	—	16—12	12—8

	GROUP II = *Plegmatograptus.*			GROUP III = *Gothograptus.*	
	P. nebula.	*P. obesus.*	var. *macilentus.*	*G. nassa.*	*G. spinosus.*
Character of polypary .	Cloud-like	Fairly long and relatively broad after rapid widening	—	Small and narrow with uniform breadth	Rapidly widening from proximal region
Reticula	Irregular and ill defined	Filamentous, with sub-hexagonal meshes near ventral margins	Wide hexagonal meshes throughout	Conspicuous meshes minute	Coarse and irregular
Clathria	Indistinguishable	Ill defined	—	Ill defined	Fairly well defined
Maximum width . .	2 mm.	8 mm.	—	1 mm.	1·8 mm.
No. of thecæ in 10 mm. .	12	12—9	—	15	11—10 with apertural spines

Affinities.—*Gothog. spinosus* is readily distinguished from all other British *Retiolites* by its isolated apertural spines.

Horizon and Localities.—Lower Ludlow Shales (zone of *Monog. Nilssoni*).

Wales: Hospital Road, Builth; Irfon River, Builth. *Shropshire*: Middletown Brook, Long Mountain; Montgomery Road, near Chirbury.

Associates, etc.—*Gothog. spinosus* is a fairly common fossil in the Lower Ludlow Shales (zone of *Monog. Nilssoni*) of the Welsh Borderland, where it is found in association with *Monog. Nilssoni*, *M. colonus*, *M. bohemicus*, etc. Abroad it seems to occur at a somewhat lower horizon.

Collections.—The Authors.

Family **DIMORPHOGRAPTIDÆ**, nom. nov.

1883. Family *Heteroprionidæ*, Tullberg, Skånes Graptoliter II, Sver. Geol. Undersökn., Ser. C., No. 53, p. 14.

Unibiserial Graptoloidea; proximal portion uniserial, bearing thecæ of the general *Monograptus* type; distal portion biserial, bearing thecæ of the general *Diplograptus* type. Test continuous, membranous.

In the Dimorphograptidæ we find in combination features characteristic of the Monograptidæ on the one hand and of the Diplograptidæ on the other.

Proximally, the polypary in the Dimorphograptidæ passes through what is practically a Monograptid stage: the proximal portion is uniserial, its earlier thecæ originate from the sicula in the same way as in *Monograptus*, and show the same general low inclination and slight overlap. Distally, the polypary passes into a Diplograptid stage, becoming biserial, as in *Diplograptus*, the thecæ showing a similar higher inclination and longer overlap.

In the family of the Dimorphograptidæ we enter upon the fourth of the successive types or stages in the development of the initial extremity of the Graptoloidea in general. In the most ancient or Dichograptid type, the first theca, after budding from the sicula, grows downward, and maintains this downward direction throughout the whole of its growth. In the second or Leptograptid type the first theca retains the primitive downward direction in the earlier half of its growth, but in the later half it becomes approximately horizontal. In the third or Diplograptid type only the initial part of the first theca retains the original downward direction; the middle portion is horizontal, and the terminal portion has distinctly an upward direction of growth. In the fourth or Monograptid type of development, here met with for the first time in the Dimorphograptidæ, we lose all trace of the primitive downward direction of the first theca, the growth of which is upward from the commencement.

Thus, from the systematic point of view, the Dimorphograptidæ may be regarded as constituting a family intermediate between the Diplograptidæ and the Monograptidæ.

The individuality of the family was first recognised by Tullberg, for whose original title of Heteroprionidæ we have here substituted that of Dimorphograptidæ in order to bring it into harmony with the names of the other families of the Graptoloidea.

Genus **DIMORPHOGRAPTUS**, *Lapworth.*

1876. *Dimorphograptus,* Lapworth, Geol. Mag., dec. 2, vol. iii, p. 545.

Polypary uniserial proximally, becoming biserial distally; test membranous, continuous.

Thecæ of the biserial portion of the general *Diplograptus* type; those of the uniserial portion of the *Monograptus* type.

The polypary is somewhat small as a general rule, only two species so far as known exceeding 3 cm. in extent. It may be curved or straight, and is biserial for fully one half of its entire length. The proximal uniserial portion may be short or long, bearing from one to seventeen thecæ, and when it is curved its thecæ appear to be always on the convex side of the curve; fragments of this portion are indistinguishable from some *Monograpti.*

There appears to be a certain amount of torsion in the polypary in some species, so that the uniserial and biserial portions do not grow quite in the same plane.

The sicula is conspicuous from its position; it is free for its entire extent on one side, but is more or less embraced by th. 1^1 on the other, according as the first theca arises near the aperture of the sicula or near its apex. As a rule the virgella is well shown.

The course of the virgula is easily followed; it lies on the outer edge of the polypary in the uniserial portion and passes into the middle of the biserial portion.

The thecæ in the biserial portion of the polypary are of the general *Diplograptus* type, but exhibit minor differences amongst themselves of much the same nature as those which have been noticed within that genus; and consequently the *Dimorphograpti* as a whole are capable of being similarly divided into minor groups characterised by the differences of the thecæ. These minor groups are as follows:

Group I.—*Dimorphograpti* in which the biserial thecæ are of the general *Orthograptus* type.

Type, *Dimorphog. confertus.*
D. confertus.
var. *Swanstoni.*

D. decussatus.
var. *partiliter.*
D. physophora.
D. longissimus.

GROUP II.—*Dimorphograpti* in which the biserial thecæ are of the general *Glyptograptus* type.

Type, *Dimorphog. erectus.*
D. erectus.
D. elongatus.

GROUP III.—*Dimorphograpti* in which the biserial thecæ are of the general *Amplexograptus* type.

Type, *Dimorphog. extenuatus.*
D. extenuatus.

GROUP I.

Dimorphograpti in which the biserial thecæ are of the general *Orthograptus* type.

Dimorphograptus confertus (Nicholson). Plate XXXV, figs. 3 *a—d.*

1868. *Diplograpsus confertus,* Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 526, pl. xix, figs. 14, 15.

1888. *Dimorphograptus confertus,* Marr and Nicholson, Quart. Journ. Geol. Soc., vol. xliv, p. 707, etc.

1897. *Dimorphograptus Swanstoni,* var. *Kurcki,* Törnquist, On Diplograptidæ and Heteroprionidæ of Scanian *Rastrites* Beds, p. 19, pl. ii, figs. 33, 34.

Polypary straight or stiffly curved, 2—3 cm. in length; uniserial portion short, bearing three thecæ; biserial portion always straight, 2—3 mm. in breadth. Sicula conspicuous. Thecæ fourteen to twelve in 10 mm., with slightly concave outer walls overlapping one half to two thirds their length; apertural margins everted, undulate.

Description.—The uniserial portion of the polypary has a length of about 4 mm.; it undergoes very marked increase in width from its origin towards the biserial portion, measuring ·5 mm. at the level of th. 1^1 and increasing to ·8 mm. It is, however, relatively slender compared with the biserial portion, which widens from 1·8—3 mm.; distally the margins are subparallel.

The sicula has a length of 2 mm., reaching to the level of the aperture of th. 1^1; the virgella is sometimes conspicuous and may have a length of 1 mm. or more. Th. 1^1 arises slightly above the aperture of the sicula and curves

gradually outward; from th. 3^1 two thecæ are developed, th. 1^2 from the initial part of th. 3^1 and th. 4^1 from its apertural region.

Figs. 227 *a* and *b*.—*Dimorphograptus confertus* (Nich.).

a. Obverse aspect, showing sicula and form of thecæ. Enlargement of part of Pl. XXXV, fig. 3 *d*.
b. Obverse aspect, showing sicula and virgella. Enlargement of part of Pl. XXXV, fig. 3 *c*.

The thecæ of the biserial portion are of the general *Orthograptus* type, and the margins are typically undulate. The uniserial thecæ are more distant than those of the biserial portion, approximating in form to those of *Monograptus gregarius*. Their apertural margins are rounded and the denticles are somewhat rostrate.

Affinities.—*D. confertus* resembles closely its var. *Swanstoni*, but may be distinguished by its shorter and stiffer uniserial portion, and longer and straighter biserial portion; the thecæ also are more closely set.

Horizon and Localities.—Stockdale Shales (zone of *Dimorphog. confertus*), Lower Birkhill Shales (zone of *Orthog. vesiculosus*).

Lake District: Skelgill. *S. Scotland:* Dobb's Linn. *N.E. Ireland:* Mill Sluice below Slate Quarry, Tirnaskea, Co. Tyrone.

Associates, etc.—*D. confertus* is an abundant fossil in the beds near the base of the Stockdale Shales at Skelgill, where it forms a well-recognised zone. The fossils from this locality are, however, very much distorted by cleavage and the characters of the thecæ are hard to determine. Much better specimens have been obtained from Scotland and Ireland, and from these our description has been drawn up. It will be noticed that some of the characteristics of the species as given above differ from those given by Nicholson in his original description, but this is accounted for by the better preserved material subsequently collected.

Collections.—Sedgwick Museum, Marr, Geological Survey of Scotland, Lapworth, and the Authors.

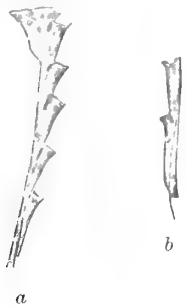
Var. **Swanstoni** (Lapworth). Plate XXXV, figs. 4 *a—f*.

1852. *Diplograptus dentatus*, Geinitz, Die Graptolithen, p. 23, pl. i, figs. 25 *a* and *b*.
1876. *Dimorphograptus Swanstoni*, Lapworth, Geol. Mag., p. 548, pl. xx, figs. 13 *a—c*.
1877. *Dimorphograptus Swanstoni*, Lapworth, Proc. Belfast Nat. Field Club, p. 131, pl. vi, fig. 5.

Var. *Swanstoni* differs from the typical species (1) in its smaller size, for it rarely exceeds 1 cm. in length; (2) the graceful curvature of the polypary; (3) the longer uniserial portion, which is composed of 5 thecæ; and (4) the greater distance of the thecæ from each other even in the biserial portion.

The sicula has a length of 2 mm. and the virgella 1 mm.; th. 1^1 originates slightly above the aperture of the sicula, and grows upward and very slightly outward, being closely adpressed to the sicula for the greater part of its length; each of the next few thecæ develops from the theca immediately below until th. 4^1 or th. 5^1 is reached; from th. 4^1 (or th. 5^1) two thecæ, th. 5^1 (or th. 6^1) and th. 1^2 are developed, th. 1^2 from the back (obverse view) of the initial portion, and th. 5^1 (or th. 6^1) from the front and apertural region, and the polypary is thenceforward biserial.

FIGS. 228 *a* and *b*.—*Dimorphograptus confertus*, var. *Swanstoni* (Lapw.).



a. Uniserial portion, obverse aspect. Donaghadee, Co. Down; Birkhill Shales. Coll. Elles.
b. Reverse aspect. Ibid.

Each of the biserial thecæ apparently buds from the theca next below it belonging to its own series; the septum, however, never seems to have been more than partial throughout its entire length. In the earlier part of the biserial portion the thecæ are markedly alternate, but they become less so towards the distal end of the polypary. The apertural margins are mainly convex, but tend to become slightly concave towards the exterior, this double curvature being most characteristic.

Affinities.—When fully developed var. *Swanstoni*, with its gracefully curved polypary, presents a most characteristic appearance. When young, however, it is liable to be confused with specimens of *Monog. gregarius* until the biserial portion commences; the thecæ in these two forms are practically identical and both have long siculæ, though that of *Monog. gregarius* is in reality far the longer. Amongst the *Dimorphograpti*, var. *Swanstoni* is certainly most closely allied to *Dimorphog. confertus*, from which it differs chiefly in its smaller size, more graceful curvature and less closely-set thecæ.

Horizon and Localities.—Lower Birkhill Shales (zones of *Cephalog.* [?] *acuminatus* and *Orthog. vesiculosus*); Stockdale Shales (zone of *Dimorphog. confertus*); Dolgadfan Shales (*Dimorphograptus* band).

S. Scotland: Dobb's Linn, etc. *Lake District:* Skelgill. *Ireland:* Coalpit Bay, Donaghadee. *C. Wales:* Pennant, near Llanbrynmair.

Associates, etc.—*Dimorphog. Swanstoni* is a fairly common fossil in the lower beds of the Lower Birkhill Shales of Scotland and their equivalents in other parts of Great Britain and Ireland. It has quite a gregarious habit in the *Orthog. vesiculosus* zone, and is commonly associated with such forms as *O. vesiculosus*, *Dimorphog. confertus*, *Climacog. normalis*, and *Monog. tenuis*. In the Scottish specimens it is noticeable that the biserial portion commences after th. 4^1, while in the Irish specimens there are 5 uniserial thecæ. The specimens from Wales are beautifully preserved in full relief, and there is no trace of a septal groove in the reverse aspect.

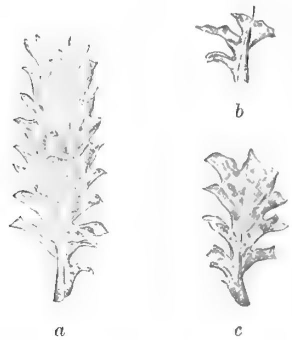
Collections.—Museum of Belfast Natural History Society, Sedgwick Museum, Lapworth, and the Authors.

Dimorphograptus decussatus, sp. nov. Plate XXXV, figs. 5 *a—c*.

Polypary 1—1·5 cm. or more in length, uniserial portion very short and slightly curved, biserial portion straight, maximum breadth 2·5 mm. Sicula conspicuous. Thecæ fourteen in 10 mm., uniserial thecæ almost isolated, biserial thecæ of general *Orthograptus* type.

Description.—The character of the uniserial portion of the polypary is unique within the genus; it is extremely short, comprising only 2 thecæ, and all the earliest thecæ are almost isolated from each other, approaching in type those characteristic of *Monog. convolutus.* In the distal portion of the polypary, however, they are of the type of *Orthograptus* and overlap about one half their length in the normal manner. The walls of the earlier biserial thecæ are strongly curved, and are inclined at a high angle, while those of the later ones are straighter and inclined at a low angle. Hence the maximum breadth of the polypary is attained near the commencement of the biserial portion.

Figs. 229 *a* and *b*.—*Dimorphograptus decussatus*, sp. nov.



a. Complete specimen, reverse aspect. Enlargement of Pl. XXXV, fig. 5 *c*.
b. Young specimen, obverse aspect, showing complete length of sicula. Main Cliff, Dobb's Linn; Birkhill Shales (*Monog. tenuis* band). Coll. Elles.
c. Young specimen, obverse aspect. Dobb's Linn; Birkhill Shales (zone of *Orthog. vesiculosus*). Coll. Elles.

The sicula has a length of 1·7 mm., but the apex is often concealed by the thecal bases; th. 1^1 arises slightly above its aperture, and, growing upward, eventually bends outward somewhat abruptly; th. 2^1 arises from th. 1^1 at the bend of the latter, and growing outward with strong curvature has both walls completely free; th. 1^2 arises from th. 2^1, and growing similarly in an opposite direction, forms an almost isolated theca on the other side of the polypary; the next two thecæ also grow in the same way, and all the proximal biserial thecæ are markedly alternate in their arrangement. After the development of th. 3^1 and th. 2^2 a partial septum seems to make its appearance within the polypary, and the thecæ on each side develop individually from the one next below; then their walls become straighter, and the amount of overlap increases until a constant breadth of 2 mm. is reached by the polypary.

Affinities.—*D. decussatus* is readily distinguishable from other *Dimorphograpti* by the characters of the uniserial thecæ.

Horizon and Localities.—Lower Birkhill Shales (zone of *Orthog. vesiculosus*).

S. Scotland: Long Linn; Main Cliff, Branch Linn, and Corrie, Dobb's Linn.

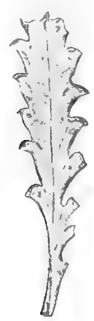
Associates, etc.—*D. decussatus* occurs somewhat rarely in the highest beds of the zone of *Orthog. vesiculosus* associated with *Climacog. rectangularis* and *Monog. tenuis*.

Collection.—Elles.

Var. **partiliter,** var. nov. Plate XXXV, fig. 6.

A variety which differs in some important respects from the typical form occurs on approximately the same horizon. In this variety the uniserial portion is longer and its thecæ are not so separated from each other, only the apertural portions of each being completely isolated. The biserial thecæ are also more distant, numbering only ten in 10 mm. As in the polypary of the typical form, however, the maximum breadth of 1·5 mm. is attained almost at the commencement of the biserial portion.

FIG. 230.—*Dimorphograptus decussatus*, var. *partiliter*, nov.



Reverse aspect. Enlargement of part of Pl. XXXV, fig. 6.

Horizon.—Lower Birkhill Shales (zone of *Orthog. vesiculosus*).

Locality.—Dobb's Linn.

Collection.—Elles.

Dimorphograptus physophora (Nicholson). Plate XXXV, figs. 7 *a*—*d*.

1868. *Diplograptus physophora*, Nicholson, Ann. and Mag. Nat. Hist. [4], vol. i, p. 56, pl. iii, fig. 7.
1880. *Diplograptus physophora*, Lapworth, Ann. and Mag. Nat. Hist. [5], vol. v, pl. v, fig. 26.

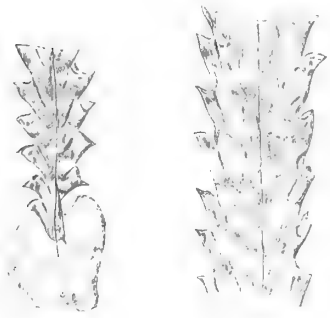
Polypary 1—3 cm. in length and with maximum breadth of 2 mm., uniserial portion very short and straight, biserial portion also straight, proximal end enclosed in a disc; sicula long, conspicuous. Thecæ nine to seven in 10 mm., overlapping one half to two thirds their length; apertural margins approximately horizontal.

Description.—The uniserial portion of the polypary in this species is practically reduced to a minimum, for it is composed of only two thecæ. Opposite the aperture of th. 1^1 the polypary measures ·7 mm. in breadth; it increases up to 1·5 mm. at the commencement of the biserial portion, and thence widens gradually till a breadth of 2 mm. is attained, when the margins continue subparallel for the remainder of their extent.

The sicula has a length of 1·5 mm. and reaches well up into the biserial portion of the polypary, terminating approximately on the level of the aperture of th. 2^1; th. 1^1 originates slightly above the aperture of the sicula and has the appearance of growing at first slightly downward, but it quickly bends round, grows upward

and outward. Th. 2^1 arises from its apertural region, and from this two thecæ are developed and the biserial portion is originated. In the reverse aspect of the polypary it can be clearly seen that th. 1^2 grows from the initial portion of th. 2^1, while th. 3^1 grows from its apertural region. Owing to this growth of th. 1^2 a considerable portion of the sicula is concealed in this aspect.

FIGS. 231 *a* and *b*.—*Dimorphograptus physophora* (Nich.).



a *b*

a. Obverse aspect, showing sicula and disc. Enlargement of part of specimen on same slab as Pl. XXXV, fig. 7 *d*.
b. Distal thecæ. Enlargement of part of specimen on same slab as Pl. XXXV, figs. 7 *a* and 7 *c*.

The whole initial region of the polypary, inclusive of the base of the biserial portion, is frequently, though not invariably, enclosed in a disc-like body which is approximately circular in form, having a diameter of about 2·5 mm.

The thecæ number ten in 10 mm.; they have an average length of 3 mm., and the overlap increases from half to two thirds in the more distal parts of the polypary; the free outer walls are nearly straight, and the apertural margins are in general slightly concave; at first they show a tendency to slight eversion, but quickly become horizontal.

Affinities.—*D. physophora* is the only *Dimorphograptus* in which a disc has hitherto been found, and when that is preserved it is easily separable from all other forms. When it is not present the polypary exhibits some features which it shares with *D. erectus.* It is, however, distinguishable by its extremely short uniserial portion and the general rigidity of the polypary.

Horizon and Locality.—Lower Birkhill Shales (zone of *Orthog. vesiculosus*).

S. Scotland: Dobb's Linn.

Associates, etc.—*D. physophora* occurs in some abundance at the top of the *Orthog. vesiculosus* zone (sub-zone *Monog. tenuis*), associated with *O. vesiculosus*, *Climacog. rectangularis*, *Cl. innotatus*, and *Monog. tenuis.*

Collections.—Lapworth and the Authors.

Dimorphograptus *cfr.* **longissimus** (Kurck). Plate XXXV, figs. 8 *a*—*d*.

1881. *Diplograptus* (?) *longissimus*, Kurck, Nya Grapt. fr. Skåne, Geol. Fören. Förhandl., vol. vi, p. 302, pl. xiv, figs. 8 and 9.

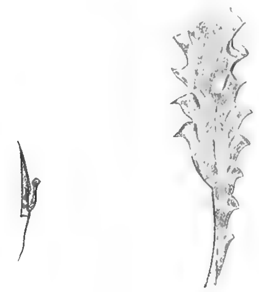
1897. Non *Diplograptus longissimus*, Törnquist, Diplograptidæ and Heteroprionidæ of Scanian *Rastrites* Beds, p. 17, pl. ii, figs. 26—29.

Polypary 2—4 cm. or more in length; biserial portion long and straight, having a maximum width of 2—2·5 mm. which is attained quickly, so that margins are subparallel; uniserial portion relatively short, 2·5 mm. in length and comprising three thecæ, slightly curved. Sicula conspicuous.

Thecæ twelve to ten in 10 mm., having an average length of 2 mm. and overlapping one half to two thirds of their length; apertural margins of thecæ of uniserial portion characteristically rostrate; those of biserial portion becoming straighter and the denticle more triangular.

Description.—The polypary must often have attained a great length, judging from the extent of various fragments occasionally found; long, perfect specimens showing the proximal end are, however, rare. These show a maximum breadth of 2·5 mm. in the biserial portion, but numerous short examples occur in which a breadth of 2 mm. is not exceeded.

Fig. 232 *a* and *b*.—*Dimorphograptus cfr. longissimus* (Kurck).



a. Sicula with long virgella and th. 1^1. Enlargement of specimen on same slab as Pl. XXXV, fig. 8 *a*.
b. Reverse aspect, showing form of thecæ. Enlargement of part of Pl. XXXV, fig. 8 *d*.

The sicula has a length of 1·7 mm., reaching to above the level of the aperture of th. 1^1. The virgella when preserved has a length of about 1 mm. Th. 1^1 originates a short distance above the aperture of the sicula, and grows upward with a gentle outward curve; three thecæ are usually developed before the biserial portion commences.

Affinities.—When fully preserved, *D. longissimus* may be distinguished by its size from all other forms except *Dimorphog. physophora*, from which it differs in having more closely-set thecæ and in the character of the proximal end. Smaller specimens have, however, a superficial resemblance to *D. erectus*, from which it may be separated by the rapidity with which it attains its maximum width, and by the rostrate apertural denticles of the uniserial thecæ.

Horizon and Localities.—Lower Birkhill Shales (zone of *Orthog. vesiculosus*). Stockdale Shales (zone of *Dimorphog. confertus*).

Lake District: Fruid Water, Tweedsmuir, quarter of a mile E. of Tarn Hows; Keisley, E. Ridlaw. *S. Scotland:* Dobb's Linn. *Ireland:* Little River, Pomeroy.

Associates, etc.—*Dimorphog. longissimus* is commonly associated with *Orthog. vesiculosus*, *Dimorphog. confertus*, *D. Swanstoni*, *Climacog. rectangularis*, and *Monog. tenuis*. It is not a very abundant form.

Collections.—Sedgwick Museum, Geological Survey of Scotland, Marr, and Elles.

Group II.

Dimorphograpti in which the thecæ are of the general *Glyptograptus* type.

Dimorphograptus erectus, sp. nov. Plate XXXV, figs. 9 *a*—*d*.

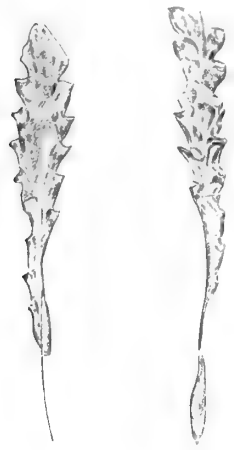
Polypary 1—2 cm. in length, biserial portion straight, with a maximum breadth of 1·5 mm.; uniserial portion short, slightly curved, comprising 3—4

thecæ. Sicula long and conspicuous, with long virgella. Thecæ ten to eleven in 10 mm., with conspicuous sigmoid curvature, overlapping one third to one half their length, excavations in biserial portion wide and deep.

Description.—The uniserial portion of the polypary has a length of 3—4 mm. and measures only ·5 mm. in breadth; but the polypary widens to 1 mm. where the biserial part commences, and thence to a maximum breadth of 1·5 mm., which is thereafter maintained.

The sicula is very conspicuous; is about 2 mm. in length, and reaches to the level of the aperture of th. 2^1; it is furnished with a long virgella which may have a length of 4 mm., and in one specimen shows a dilatation at its extremity. Th. 1^1 originates slightly above the aperture of the sicula, and grows upward and outward closely adpressed to the side of the sicula; th. 2^1 and th. 3^1 develop from the initial part of the theca next below; from th. 3^1 (or more rarely th. 4^1) two thecæ arise, th. 1^2 from the initial portion of th. 3^1 or th. 4^1, and th. 4^1 or th. 5^1 from the apertural region.

FIGS. 233 *a* and *b*.—*Dimorphograptus erectus*, sp. nov.



a *b*

a. Proximal end, obverse aspect, showing sicula and long virgella. Dobb's Linn; Birkhill Shales (zone of *Orthog. vesiculosus*). Coll. Elles.
b. Proximal end, reverse aspect, showing virgella dilating into vesicle at its extremity. Ibid.

The thecæ measure ten to eleven in 10 mm. and have an average length of 2 mm., but while in the uniserial part they overlap one third of their length, in the biserial portion the overlap increases to one half. The thecæ of the biserial portion closely resemble those of *Glyptog. tamariscus.*

Affinities.—A characteristic feature of the polypary in both the species included in this group is its gradual increase in breadth, there being no sudden increase where the biserial portion commences, but a steady widening throughout from the initial portion of the uniserial part until the maximum breadth is attained in the biserial portion. From *Dimorphog. extenuatus* it is readily distinguished by the shortness of the uniserial portion.

Horizon and Localities.—Lower Birkhill Shales (zone of *Orthog. vesiculosus*), Stockdale Shales (zone of *Dimorphog. confertus*).

Lake District: Spengill Head. *S. Scotland:* Dobb's Linn. *Ireland:* Little River, Pomeroy.

Associates, etc.—*Dimorphog. erectus* is a fairly common fossil in the zone of *Orthog. vesiculosus* of S. Scotland, where it is found associated with *Dimorphog. confertus* and var. *Swanstoni*, *Orthog. vesiculosus*, and *Climacog. rectangularis.* In the Lake District it has been found in the *D. confertus* band at Spengill Head.

Collections.—Sedgwick Museum, Marr, and Elles.

Dimorphograptus elongatus, Lapworth. Plate XXXV, figs. 11 *a—c*.

1876. *Dimorphograptus elongatus*, Lapworth, Geol. Mag., p. 547, pl. xx, figs. 12 *a*, *b*.
1877. *Dimorphograptus elongatus*, Lapworth, Proc. Belfast Nat. Field Club, p. 132, pl. vi, fig. 6.

Polypary 3·5—5 cm. in length; uniserial portion very long and curved; biserial portion approximately straight, with a maximum breadth of 1·5 mm. Sicula small, virgella long and conspicuous. Thecæ eight in 10 mm., of the general *Glyptograptus* type; apertural margins introverted with acute denticle, situated in shallow excavations occupying one quarter of the breadth of the polypary.

Description.—The uniserial portion of the polypary is much longer than in any other *Dimorphograptus*, being fully 2·5 cm. in length, and it widens gradually from ·3 mm. near the sicula till the breadth of 1·5 mm. is attained.

Figs. 234 *a* and *b*.—*Dimorphograptus elongatus*, Lapw.

a. Proximal extremity, reverse aspect, showing sicula and long virgella. Enlargement of part of Pl. XXXV, fig. 11 *b*.
b. Distal thecæ. Enlargement of part of Pl. XXXV, fig. 11 *a*.

The sicula has a length of nearly 2 mm., and th. 1[1] appears to originate from a point half way along its length.

There are commonly seventeen thecæ in the uniserial portion, th. 17[1] giving origin to the first two thecæ of the biserial portion; in this the thecæ are alternate in their arrangement, and their apertural margins seem to become more and more introverted, and some near the distal end of the polypary appear to be also introtorted.

Affinities.—When fully grown *D. elongatus* is a well-characterised and easily recognisable species. Superficially it somewhat resembles *D. extenuatus*, but differs in the curvature and length of the uniserial portion and in the characters of the thecæ. Fragments of it are very hard to identify, for the thecæ of the uniserial portion closely resemble those of *Monog. tenuis*, and those of the biserial part are not unlike those of *Cephalog.* (?) *acuminatus*, which occurs in association with the present species.

Horizon and Localities.—Lower Birkhill Shales (zones of *Cephalog.* [?] *acuminatus* and *Orthog. vesiculosus*); Stockdale Shales (zone of *Dimorphog. confertus*).

Lake District: Skelgill. *S. Scotland:* Dobb's Linn; Craigmichan. *Ireland:* Coalpit Bay, Donaghadee (?).

Associates, etc.—*D. elongatus* is a rare fossil at the base of the Birkhill Shales and Stockdale Shales. It occurs associated with *Cephalog.* (?) *acuminatus*, *Dimorphog. confertus* and var. *Swanstoni*, *Orthog. vesiculosus*, and *Monog. tenuis*.

Collections.—Lapworth and the Authors.

GROUP III.

Dimorphograpti in which the thecæ are of the general *Amplexograptus* type.

Dimorphograptus extenuatus, sp. nov. Plate XXXV, figs. 10 *a—e*.

Polypary 2—3 cm. or more in length; uniserial and biserial portions both sinuous; maximum breadth 1·6 mm. Sicula long, with conspicuous virgella. Thecæ ten to thirteen in 10 mm. of the general *Amplexograptus* type, with sharp sigmoid curvature; apertural margins opening within semi-elliptical excavations, occupying nearly one half the breadth of the polypary.

Description.—The uniserial portion has a length of 8 mm.; it is slender, measuring only ·3 mm. in breadth at its origin, and widening to ·4 mm. close to the biserial portion, so that the general increase in width is very gradual. The biserial portion measures ·7 mm. opposite the aperture of th. 1^2, and widens steadily until the maximum breadth is attained.

FIG. 235.—*Dimorphograptus extenuatus*, sp. nov.

Proximal extremity, reverse aspect. Enlargement of part of Pl. XXXV, fig. 10 *d*.

The sicula has a length of 2·5 mm. and reaches nearly to the level of the aperture of th. 2^1; the virgella is often 2 mm. in extent. Th. 1^1 originates at a point some little distance above the aperture of the sicula, which is thus free in the whole of its apertural region. There are commonly five thecæ in the uniserial portion.

In the biserial portion the thecæ are shorter and measure thirteen in 10 mm., as opposed to ten in 10 mm. in the uniserial part, and they overlap for about one third of their length, which does not exceed 1·4 mm. The distal parts of their ventral walls are free and almost vertical, so that they resemble those of *Amplexog. perexcavatus*, and come very close in form to those of a typical *Climacograptus*.

Affinities.—The characters of its thecæ are sufficient to distinguish *D. extenuatus* from all other *Dimorphograpti*.

Horizon and Localities.—Lower Birkhill Shales (zone of *Orthog. vesiculosus*).

S. Scotland: Dobb's Linn. *Ireland:* Coalpit Bay, Donaghadee. Side Valley, Little River, Pomeroy.

Associates, etc.—*D. extenuatus* occurs as a rare fossil in the *Orthog. vesiculosus* zone of the Lower Birkhill Shales in S. Scotland and N. E. Ireland. It is commonly associated with *Orthog. vesiculosus* and *Climacog. rectangularis*.

Collections.—Museum of Belfast Natural History Society, and Elles.

PLATE XXXII.

Sub-genera **Petalograptus** and **Cephalograptus**; genus **Cryptograptus.**

FIGS.

1 *a—d.—Petalograptus palmeus* (Barrande). (Page 274.)

1 *a.* Typical specimen, with long virgular tube. Dobb's Linn, S. Scotland. Birkhill Shales. Lapworth's Collection.

1 *b.* Typical specimen, showing sicula. Dobb's Linn. Birkhill Shales (band with *Monog. Clingani*). Lapworth's Collection.

1 *c.* Wider specimen, obverse aspect. Ibid.

1 *d.* Wide specimen, doubtfully referable to this species. Dobb's Linn. Birkhill Shales (zone of *Monog. gregarius*). Geological Survey of Scotland, Edinburgh.

2 *a—f.—Petalograptus palmeus,* var. *latus* (Barrande). (Page 275.)

2 *a.* Typical specimen, obverse aspect. Dobb's Linn. Birkhill Shales. Lapworth's Collection.

2 *b.* Typical specimen, reverse aspect. Ibid.

2 *c.* Shorter specimen, somewhat compressed. Dobb's Linn. Birkhill Shales. Sedgwick Museum.

2 *d.* Small specimen, figured Elles, 'Quart. Journ. Geol. Soc.,' 1897, vol. liii, pl. xiv, fig. 3. Garple Linn, near Beattock. Birkhill Shales (zone of *Monog. gregarius*). Sedgwick Museum.

2 *e.* Characteristic small specimen, showing virgella, reverse aspect. Long Linn, Dobb's Linn. Birkhill Shales (zone of *Monog. gregarius*). Elles' Collection.

2 *f.* Small specimen, obverse aspect. Ibid.

3 *a—d.—Petalograptus palmeus,* var. *tenuis* (Barrande). (Page 276.)

3 *a.* Typical specimen, cast, showing fine growth-lines. Dobb's Linn ? Birkhill Shales. Lapworth's Collection.

3 *b.* Typical specimen, showing sicula, figured Elles, 'Quart. Journ. Geol. Soc.,' 1897, vol. liii, pl. xiv, fig. 9. Pull Beck, Lake District. Browgill Beds (zone of *Monog. crispus*). Sedgwick Museum.

3 *c.* Small specimen in full relief, showing sicula, ? figured Elles, Ibid., fig. 10. Dobb's Linn. Birkhill Shales. Lapworth's Collection.

3 *d.* Specimen in relief, showing no septum, reverse aspect. Morben Quarry, Derwentas, Machynlleth. Llandovery. G. J. Williams' Collection.

4 *a—d.—Petalograptus palmeus,* var. *ovato-elongatus* (Kurck). (Page 277.)

4 *a.* Typical specimen, showing virgula. Long Linn, Dobb's Linn. Birkhill Shales (zone of *Monog. gregarius*). Elles' Collection.

4 *b.* Specimen somewhat compressed. Branch Linn, Dobb's Linn. Birkhill Shales (zone of *Cephalog. cometa*). Elles' Collection.

4 *c.* Longer specimen, in partial relief. Dobb's Linn. Birkhill Shales. Geological Survey of Scotland, Edinburgh.

4 *d.* Incomplete specimen. Ibid.

5 *a—e.—Petalograptus minor,* Elles. (Page 279.)

5 *a.* Typical specimen, in full relief, showing no septum, reverse aspect, figured, Elles, 'Quart. Journ. Geol. Soc.,' 1897, vol. liii, pl. xiv, fig. 19. Skelgill, Skelgill Beds. Sedgwick Museum.

5 *b.* Similar specimen from same locality as fig. 5 *a.*

5 *c.* Typical specimen, obverse aspect. Long Linn, Dobb's Linn. Birkhill Shales (zone of *Monog. gregarius*). Elles' Collection.

5 *d.* Larger specimen on same slab as fig. 5 *c.*

5 *e.* Characteristic small specimen, showing growth-lines. Dobb's Linn. Birkhill Shales (zone of *Monog. gregarius*). Sedgwick Museum.

6.—*Petalograptus cfr. ovatus* (Barrande). (Page 278.)

Compressed specimen. Skelgill. Browgill Beds. Sedgwick Museum.

7 *a—e.—Petalograptus altissimus,* Elles and Wood, nov. (Page 281.)

7 *a.* Typical specimen, in relief. Ettrick Bridge End, Selkirk. Upper Birkhill Shales. Geological Survey of Scotland, Edinburgh.

7 *b.* Less complete specimen. Dobb's Linn. Upper Birkhill Shales (zone of *Rastrites maximus*). Lapworth's Collection.

7 *c.* Narrow specimen, in high relief, 200 yards S. of Parbryn Sands, Cardiganshire. Llandovery-Tarannon. O. T. Jones' Collection.

7 *d.* Distal fragment in relief. Llanystwmdwy near Criccieth. Llandovery-Tarannon (zone of *Monog. turriculatus*). Fearnsides' Collection.

7 *e.* Flattened specimen. Woopland. Gala Beds. Lapworth's Collection.

8 *a—e.—Petalograptus folium* (Hisinger). (Page 282.)

8 *a.* Typical specimen (faulted), reverse aspect, figured, Elles, 'Quart. Journ. Geol. Soc.,' 1897, vol. liii, pl. xiii, fig. 1. Belcraig, near Moffat. Birkhill Shales (zone of *Monog. gregarius*). Elles' Collection.

8 *b.* Fragment of proximal end. Main Cliff, Dobb's Linn. Birkhill Shales (band with *P. folium*). Elles' Collection.

FIGS.

8 *a*—*e*.—*Petalograptus folium* (Hisinger)—*continued*.

8 *c*. Narrower specimen. Ibid.

8 *d*. Fragment of narrower specimen. Branch Linn, Dobb's Linn. Birkhill Shales (band with *P. folium*). Elles' Collection.

8 *e*. Fragment of proximal end. Ibid.

9 *a*—*d*.—*Cephalograptus tubulariformis* (Nicholson). (Page 287.)

9 *a*. Typical specimen, reverse aspect, figured ? Nicholson, 'Geol. Mag.,' 1867, pl. vii, fig. 12, and Elles, as *Cephalog. petalum*, 'Quart. Journ. Geol. Soc.,' 1897, vol. liii, pl. xiii, fig. 8. Frenchland Burn, near Moffat. Birkhill Shales. British Museum (Natural History), S. Kensington.

9 *b*. Proximal end, reverse aspect, figured, Elles, ibid., fig. 7. Duffkinnell Burn, near Wamphray. Birkhill Shales. British Museum (Natural History), S. Kensington.

9 *c*. Long specimen. Belcraig Burn, near Moffat. Birkhill Shales (zone of *Cephalog. cometa*). Elles' Collection.

9 *d*. Typical specimen incomplete, figured Elles, as *Cephalog. petalum*, 'Quart. Journ. Geol. Soc.,' 1897, vol. liii, pl. xiii, fig. 6. Duffkinnell Burn, near Wamphray. Birkhill Shales. British Museum (Natural History), S. Kensington.

10 *a*—*d*.—*Cephalograptus cometa* (Geinitz). (Page 285.)

10 *a*. Typical specimen partly in relief. Pary's Mountain, Anglesea. Llandovery. G. J. Williams' Collection.

10 *b*. Very long specimen. Dobb's Linn. Birkhill Shales (zone of *Cephalog. cometa*). Lapworth's Collection.

10 *c*. Well-preserved, very typical specimen. Dobb's Linn. Birkhill Shales. Geological Survey of Scotland, Edinburgh.

10 *d*. Distal fragment, showing virgula, figured Elles, 'Quart. Journ. Geol. Soc.,' 1897, vol. liii, pl. xiii, fig. 10. Duffkinnell Burn, near Wamphray. British Museum (Natural History), S. Kensington.

11 *a*—*d*.—*Cephalograptus* (?) *acuminatus* (Nicholson). (Page 289.)

11 *a*. Typical specimen. Dobb's Linn. Birkhill Shales (zone of *Cephalog.* (?) *acuminatus*). Lapworth's Collection.

11 *b*. Smaller specimen, straighter. Duffkinnell Burn, near Wamphray. Birkhill Shales. Lapworth's Collection.

11 *c*. Small specimen. Dobb's Linn. Birkhill Shales. Lapworth's Collection.

11 *d*. Longer straight specimen. Dobb's Linn. Birkhill Shales (zone of *Cephalog.* (?) *acuminatus*). Sedgwick Museum.

12 *a*—*d*.—*Cryptograptus tricornis* (Carruthers). (Page 296.)

12 *a*. Long typical specimen, poorly preserved. The Cornice, Hartfell. Hartfell Shales. Lapworth's Collection.

12 *b*. Ibid.

12 *c*. Smaller specimen. The Cornice, Hartfell. Hartfell Shales (zone of *Climacog. Wilsoni*). Elles' Collection.

12 *d*. Small specimen. Blaen-y-delyn Quarry, Fishguard. Llanvirn Beds. F. R. C. Reed's Collection.

13 *a*—*c*.—*Cryptograptus tricornis*, var. *Schäferi*, Lapworth. (Page 299.)

13 *a*. Typical specimen. Llandrindod Wells. Llandeilo. Lapworth's Collection.

13 *b*. Wider specimen. Pencerrig, near Builth. Llandeilo. Sedgwick Museum.

13 *c*. Same locality etc., as fig. 13 *a*.

14 *a*—*e*.—*Cryptograptus* (?) *antennarius* (Hall). (Page 300.)

14 *a*. Typical specimen with very long basal spines. Outerside, Keswick. Skiddaw Slates. British Museum (Natural History), S. Kensington.

14 *b*. Smaller specimen, figured Elles, 'Quart. Journ. Geol. Soc.,' 1898, vol. liv, p. 520, fig. 31 *a*. Outerside. Skiddaw Slates. Sedgwick Museum.

14 *c*. Specimen showing additional spines, figured ibid., fig. 31 *c*. Ibid.

14 *d*. Specimen showing virgular tube. Ibid.

14 *e*. Small specimen (young), figured Elles, ibid., fig. 31 *b*. Ibid.

15 *a*, *b*.—*Cryptograptus Hopkinsoni* (Nicholson). (Page 299.)

15 *a*. Typical specimen, mentioned, Elles 'Quart. Journ. Geol. Soc.,' 1898, vol. liv, p. 521. Outerside, Keswick. Skiddaw Slates. Sedgwick Museum.

15 *b*. Distal fragment. Ibid. British Museum (Natural History), S. Kensington.

16 *a*—*e*.—*Petalograptus* (?) *phylloides*, Elles and Wood, nov. (Page 284.)

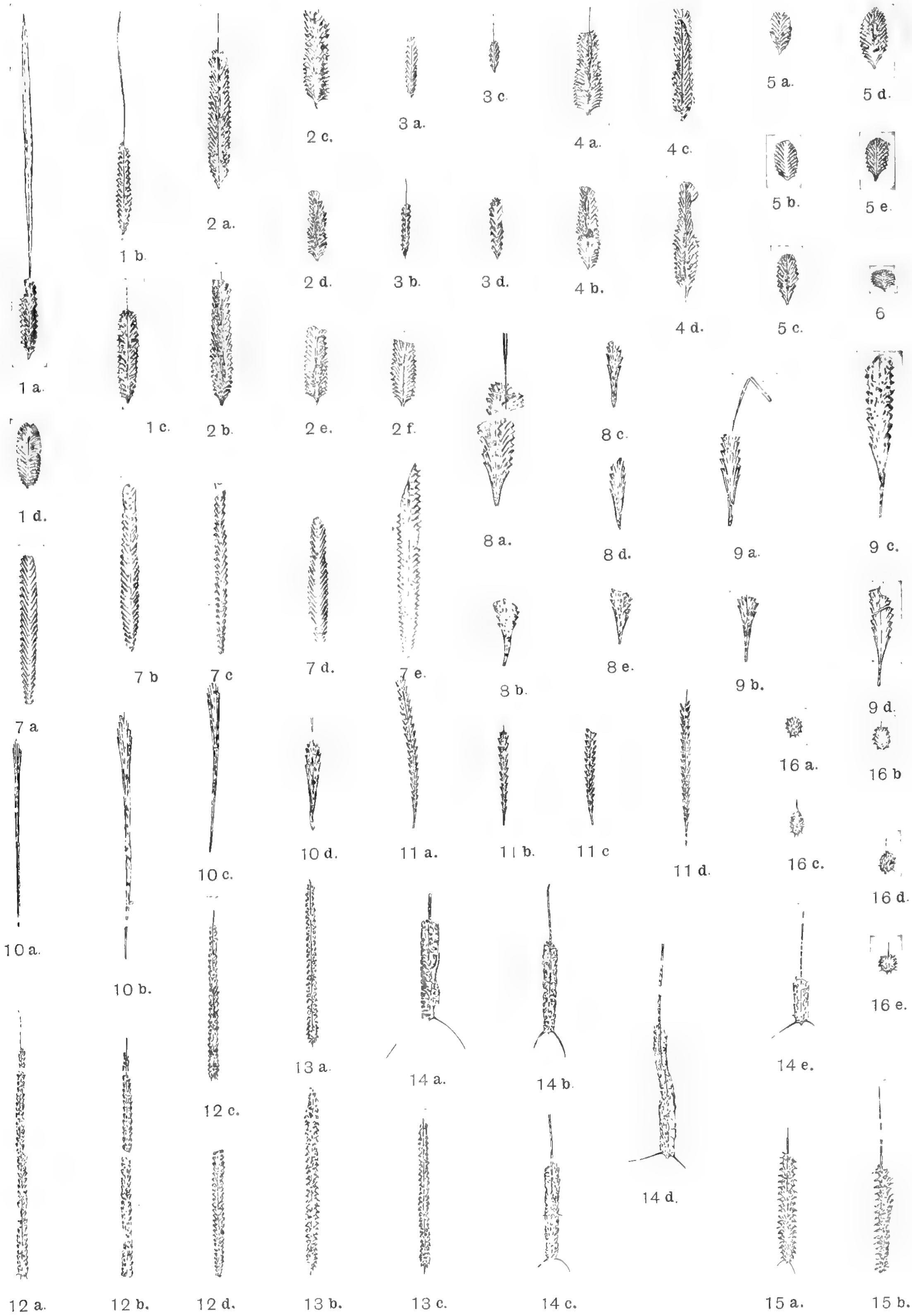
16 *a*. Typical small specimen. Belcraig Burn. Glenkiln Shales (zone of *Nemag. gracilis*). Elles' Collection.

16 *b*. Ibid.

16 *c*. Narrower specimen. Ibid. Wood's Collection.

16 *d*. Specimen showing sicula. Ibid.

16 *e*. Young specimen with sicula. Dobb's Linn. Glenkiln Shales (zone of *Dicellog. patulosus*). Elles' Collection.



PETALOGRAPTUS, CEPHALOGRAPTUS AND CRYPTOGRAPTUS.

E. M. R. WOOD, del. Bemrose Ltd., Derby.

PLATE XXXIII.

Genus **Glossograptus** and Sub-genus **Hallograptus**.

FIGS.

1.—*Glossograptus cfr. ciliatus*, Emmons. (Page 309.)
Small specimen (young). Ty Obry, near Portmadoc. Llandeilo. Sedgwick Museum.

2 *a*—*j*.—*Glossograptus Hincksii* (Hopkinson). (Page 309.)
2 *a*. Typical specimen, bi-profile view, showing apertural spines. Wanlock Head. Glenkiln Shales. Lapworth's Collection.
2 *b*. Typical specimen, sub-scalariform view, showing septal and apertural spines and thread-like virgula. Ibid.
2 *c*. Small specimen, scalariform view showing septal spines. On same slab as 2 *a*.
2 *d*. Specimen in sub-scalariform view, showing septal spines, septal strand, and virgula. Ibid.
2 *e*. Young form, showing numerous spines in the proximal region. Hartfell (?). Hartfell Shales. Lapworth's Collection.
2 *f*. Long specimen, with robust apertural spines. Hartfell. Hartfell Shales (zone of *Climacog. Wilsoni*). Sedgwick Museum.
2 *g*. Fragment, showing septal and apertural spines. Hartfell. Hartfell Shales (zone of *Climacog. Wilsoni*). Lapworth's Collection.
2 *h*. Narrow specimen, bi-profile view. Ibid.
2 *i*. Short specimen, sub-scalariform view, showing septal and apertural spines and robust virgular tube. Birnock Water. Glenkiln Shales. Lapworth's Collection.
2 *j*. Similar specimen. Ibid.

3 *a*—*d*.—*Glossograptus Hincksii*, var. *fimbriatus* (Hopkinson). (Page 312.)
3 *a*. Typical specimen, figured Elles, 'Quart. Journ. Geol. Soc.,' 1898, vol. liv, p. 521, fig. 32. Ellergill. Skiddaw Slates (Ellergill Beds). Sedgwick Museum.
3 *b*. Somewhat distorted specimen. Rein Gill, Wandel Burn. Glenkiln Shales. Geological Survey of Scotland, Edinburgh.
3 *c*. Young form. Minnoch Water, opposite Glencaird Lodge, W. of Glen o'Trool. Glenkiln Shales. Ibid.
3 *d*. Typical specimen, broad. Wandel Water. Ibid.

4 *a*—*c*.—*Glossograptus acanthus*, Elles and Wood, nov. (Page 314.)
4 *a*. Typical specimen showing robust apertural spines. Sruffaunduff, ½ mile W. of summit of Bencraff, Connemara. Arenig. Muff and Carruthers' Collection.
4 *b*. Incomplete specimen, figured Hopkinson and Lapworth as *Glossog. ciliatus*, 'Quart. Journ. Geol. Soc.,' 1875, vol. xxxi, pl. xxxiv, figs. 7 *a*—*c*. Llanvirn Quarry, Pembrokeshire. Llanvirn Beds. Sedgwick Museum.
4 *c*. Small specimen, distorted by cleavage. Nant-yr-Orlof, near Arenig. Arenig (zone of *Didymog. bifidus*). Fearnsides' Collection.

5 *a*—*e*.—*Glossograptus armatus*, Nicholson. (Page 312.)
5 *a*. Poorly preserved specimen, figured Nicholson, 'Ann. Mag. Nat. Hist.' [4], vol. iv, pl. xi, fig. 8. Thornship Beck, near Shap. Skiddaw Slates. British Museum (Natural History).
5 *b*. Specimen in sub-scalariform view. Kirriereoch Burn, Minnoch Water. Glenkiln Shales. Geological Survey of Scotland, Edinburgh.

PLATE XXXIII—*continued.*

Figs.

5 *a—e.*—*Glossograptus armatus*, Nicholson—*continued.*

5 *c.* Scalariform view, showing septal spines, described Elles, 'Quart. Journ. Geol. Soc.,' 1898, vol. liv, p. 522. Thornship Beck. Skiddaw Slates (Ellergill Beds). Sedgwick Museum.

5 *d.* Somewhat distorted specimen, showing long basal spines. Back Burn, $\frac{3}{4}$ mile W. of Nether Cog, Crawick Water. Glenkiln Shales. Geological Survey of Scotland, Edinburgh.

5 *e.* Distal fragment, bi-profile view. Polmorlach Burn, Dumfries. Glenkiln Shales. Ibid.

6 *a—e.*—*Hallograptus mucronatus* (Hall). (Page 320.)

6 *a.* Characteristic specimen, bi-profile view. Cairn Ryan. Glenkiln Shales. Sedgwick Museum.

6 *b.* Distal fragment. Ibid.

6 *c.* Typical specimen. Glenkiln Burn. Glenkiln Shales (zone of *Nemag. gracilis*). Elles' Collection.

6 *d.* Smaller specimen. Cairn Ryan. Glenkiln Shales. Sedgwick Museum.

6 *e.* Scalariform view, showing scopulæ. Glenkiln Burn. Glenkiln Shales. Lapworth's Collection.

7 *a—e.*—*Hallograptus mucronatus*, var. *inutilis* (Hall). (Page 322.)

7 *a.* Incomplete specimen, bi-profile view. Half mile W. of Bencraff, Connemara. Arenig. Muff and Carruthers' Collection.

7 *b.* Distal fragment, showing virgula. Ibid.

7 *c.* Ibid.

7 *d.* Narrower specimen. Ibid.

7 *e.* Distal fragment. Ibid.

8 *a—e.*—*Hallograptus mucronatus*, var. *bimucronatus* (Nicholson). (Page 323.)

8 *a.* Typical specimen, bi-profile view. Gairy near head of Garryhorn Burn, Carsphairn. Glenkiln Shales. Geological Survey of Scotland, Edinburgh.

8 *b.* Long specimen, bi-profile view. Water of Deugh, a few yards below the moor. Glenkiln Shales. Geological Survey of Scotland, Edinburgh.

8 *c.* Small specimen, bi-profile view. Glenkiln Burn. Glenkiln Shales. Lapworth's Collection.

8 *d.* Specimen in scalariform view, showing scopulæ. Glenkiln Burn? Glenkiln Shales. Lapworth's Collection.

8 *e.*—Distal fragment, scalariform view, showing scopulæ. Polmorlach Burn, Dumfries. Glenkiln Shales. Geological Survey of Scotland, Edinburgh.

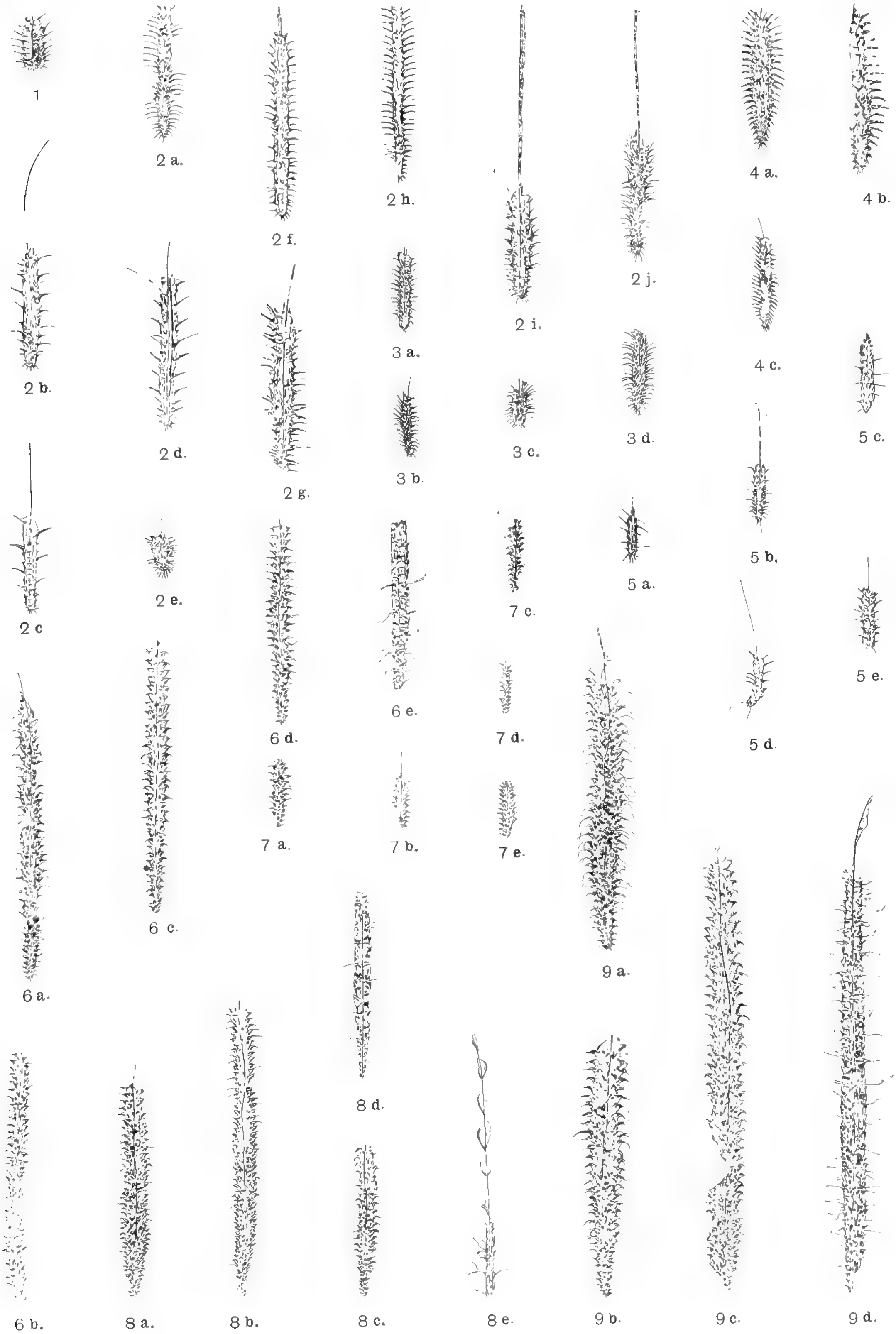
9 *a—d.*—*Hallograptus mucronatus*, var. *nobilis*, Elles and Wood, nov. (Page 324.)

9 *a.* Well-preserved specimen, bi-profile view, showing septal strand and virgula. Burn W.N.W. of Low Glenling, seven miles W. by S. of Wigtown. Glenkiln Shales. Geological Survey of Scotland, Edinburgh.

9 *b.* Specimen showing proximal end. Ibid.

9 *c.* Long distal fragment, on same slab as 9 *b.* Ibid.

9 *d.* Long specimen, sub-scalariform view with scopulæ. Ibid.



GLOSSOGRAPTUS AND HALLOGRAPTUS.

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PLATE XXXIV.

Sub-genera **Thysanograptus, Nymphographus, Neurograptus, Gladiograptus, Plegmatograptus,** and **Gothograptus;** and Genus **Retiograptus.**

FIGS.

1 *a—d.—Thysanograptus Harknessi* (Nicholson). (Page 325.)

1 *a.* Typical specimen with incomplete lacinia. Hartfell. Hartfell Shales. British Museum (Natural History). Specimen labelled by Nicholson. (? Type.)

1 *b.* Broader form with more complete lacinia. Hartfell. Hartfell Shales (zone of *Climacog. Wilsoni*). Geological Survey of Scotland, Edinburgh.

1 *c.* Sub-scalariform view, on same slab as fig. 1 *b.*

1 *d.* Broad specimen, with incomplete lacinia. Hartfell. Hartfell Shales (zone of *Climacog. Wilsoni*). Geological Survey of Scotland, Edinburgh.

2 *a—d.—Thysanograptus Harknessi*, var. *costatus* (Lapworth). (Page 327.)

2 *a.* Typical specimen. Cog Burn, a few yards above junction with Polroisk, Dumfriesshire. Glenkiln Shales. Geological Survey of Scotland, Edinburgh.

2 *b.* Type specimen, with well-developed lacinia, figured Lapworth, "Grapt. Co. Down," 'Proc. Belfast Nat. Field Club,' pl. vi, fig. 26. Dobb's Linn. Hartfell Shales (zone of *Climacog. Wilsoni*). Lapworth's Collection.

2 *c.* Specimen in very low relief. Oakwood, Pontesford, Shropshire. Llandeilo-Bala. Benson's Collection.

2 *d.* Specimen with incomplete lacinia. Dobb's Linn. Hartfell Shales. Lapworth's Collection.

3 *a—c.—Thysanograptus retusus* (Lapworth). (Page 328.)

3 *a.* Type specimen, figured Lapworth, 'Ann. Mag. Nat. Hist.' [5], vol. v, pl. v, figs. 24 *a—d.* Llandrindod Wells. Llandeilo. Lapworth's Collection.

3 *b.* Specimen showing virgula, doubtfully referable to this species. Hartfell Spa? Glenkiln Shales? Lapworth's Collection.

3 *c.* Broad specimen with virgula. Cwm Brith Bank, near Llandrindod Wells. Upper Arenig. Collection Miss C. Chamberlain.

4 *a, b.—Nymphograptus velatus*, Elles and Wood, nov. (Page 329.)

4 *a.* Two specimens in association, with well-developed lacinia. Ettrick Bridge End, Selkirk. Hartfell Shales (zone of *Dicellog. anceps*). Geological Survey of Scotland, Edinburgh.

4 *b.* Smaller fragment, with less perfect lacinia, profile view. Ibid.

5 *a—c.—Neurograptus fibratus* (Lapworth). (Page 331.)

5 *a.* Type specimen, bi-profile view, ? figured Lapworth, 'Cat. West. Scott. Foss.,' pl. iii, fig. 62. Dobb's Linn. Hartfell Shales. Lapworth's Collection.

5 *b.* Reverse of 5 *a.* Ibid.

5 *c.* Specimen in scalariform view, showing scopulate processes. Ibid.

6 *a—e.—Neurograptus margaritatus* (Lapworth). (Page 332.)

6 *a.* Typical specimen, with almost complete lacinia. Dobb's Linn. Hartfell Shales (zone of *Dicranog. Clingani*). Lapworth's Collection.

6 *b.* Similar specimen with less perfect lacinia. Ibid.

6 *c.* Specimen in scalariform view, on same slab as 6 *a.*

6 *d.* Larger specimen, with incomplete lacinia. Hartfell Spa. Hartfell Shales. Wood's Collection.

6 *e.* Distal fragment on same slab as 6 *d.*

7 *a—d.—Retiograptus Geinitzianus*, Hall. (Page 316.)

7 *a.*—Specimen in low relief. Benan Burn, river Stinchar, Girvan. Glenkiln Shales. Geological Survey of Scotland, Edinburgh.

7 *b.* Larger specimen, compressed. Birnock Water. Glenkiln Shales. Lapworth's Collection.

7 *c.* Proximal fragment. Ibid.

7 *d.* Part of ventral lattice. Ibid.

8 *a—d.—Gladiograptus Geinitzianus* (Barrande). (Page 336.)

8 *a.* Well-preserved specimen in low relief, reverse aspect. Burn, Nether Stennis Water, 6½ miles N.N.W. of Langholm. Riccarton Beds. Geological Survey of Scotland, Edinburgh.

8 *b.* Compressed specimen, showing reticula, obverse aspect. Pull Beck. Browgill Beds (zone of *Monog. crispus*). Sedgwick Museum (Coll. Marr).

8 *c.* Smaller specimen from same locality as 8 *a.*

8 *d.* Somewhat narrow specimen. Grieston Quarry, Innerleithen. Upper Gala Beds. Lapworth's Collection.

PLATE XXXIV—*continued.*

FIGS.

9 *a—c.*—*Gladiograptus Geinitzianus*, var. *angustidens*, Elles and Wood, nov. (Page 338.)

9 *a.* Long characteristic specimen. North end Falbogue Bay, W. side Meikle Ross, Kircudbright Bay. Riccarton Beds. Geological Survey of Scotland, Edinburgh.

9 *b.* Distal fragment. Swindale, Lake District. Browgill Beds. Fearnsides' Collection.

9 *c.* Proximal fragment. Ibid.

10 *a—f.*—*Gladiograptus perlatus* (Nicholson). (Page 338.)

10 *a.* Type specimen. Mosedale in Long Sleddale, Lake District. Stockdale Shales. British Museum (Natural History).

10 *b.* Specimen showing "floors" of thecæ in proximal region. Cramalt, Meggat Water. Birkhill Shales (zone of *Monog. Sedgwicki*). Lapworth's Collection.

10 *c.* Specimen showing reticula throughout. Ibid.

10 *d.* Well-preserved specimen showing thecal floors and zig-zag septal strand. Coalpit Bay, Donaghadee. Birkhill Shales (zone of *Monog. gregarius*). Belfast Natural History Museum.

10 *e.* Small specimen on same slab as 10 *b.*

10 *f.* Wide fragment, possibly referable to this species. Carrifran. Birkhill Shales? Lapworth's Collection.

11. *Gladiograptus perlatus*, var. *Daironi* (Lapworth). (Page 340.)

Type specimen, figured Lapworth, "Grapt. Co. Down," 'Proc. Belfast Nat. Field Club,' pl. vi, fig. 30. Craigmichan. Birkhill Shales. Lapworth's Collection.

12 *a—c.*—*Plegmatograptus obesus* (Lapworth). (Page 342.)

12 *a.* Typical specimen, bi-profile view, showing reticula, etc. Elwand Water, Melrose. Gala Beds. Lapworth's Collection.

12 *b.* Type specimen, figured Lapworth, 'Cat. West. Scott. Foss.,' pl. iii, fig. 61. Ibid.

12 *c.* Specimen, scalariform view. Ibid.

13 *a, b.*—*Plegmatograptus obesus*, cfr. var. *macilentus* (Törnquist). (Page 343.)

13 *a.* Incomplete fragment, showing wide meshed reticula. Swindale Beck, Knock, Lake District. Browgill Beds (zone of *Monog. crispus*). Sedgwick Museum.

13 *b.* Fragment, showing lacinia. Swindale Beck, Knock. Browgill Beds (zone of *Monog. crispus*). Fearnsides' Collection.

14 *a—d.*—*Plegmatograptus nebula*, Elles and Wood, nov. (Page 340.)

14 *a.* Profile view, showing lacinia and virgella. Morrach Bay, Portpatrick. Hartfell Shales (zone of *Dicranog. Clingani* ?). Geological Survey of Scotland, Edinburgh.

14 *b.* On same slab as 14 *a*, but lying at right angles, sub-scalariform view.

14 *c.* Profile view of small broad specimen, showing lacinia. Ibid.

14 *d.* Very wide specimen, doubtfully referable to this species. Wood of Cree, Newton Stewart. Hartfell Shales (zone of *Dicranog. Clingani*). Geological Survey of Scotland, Edinburgh.

15 *a—d.*—*Gothograptus nassa* (Holm). (Page 343.)

15 *a.* Specimen in low relief, showing "lappets." Elton Lane, near Ludlow. Lower Ludlow Shales. Wood's Collection.

15 *b.* Small specimen, showing proximal end with long virgella. Cefn-Gwyn, 1 mile E. of Eglwys Bach, East side of Conway Valley. Denbighshire Flags. Elles' Collection.

15 *c.* Broad distal fragment. Ibid.

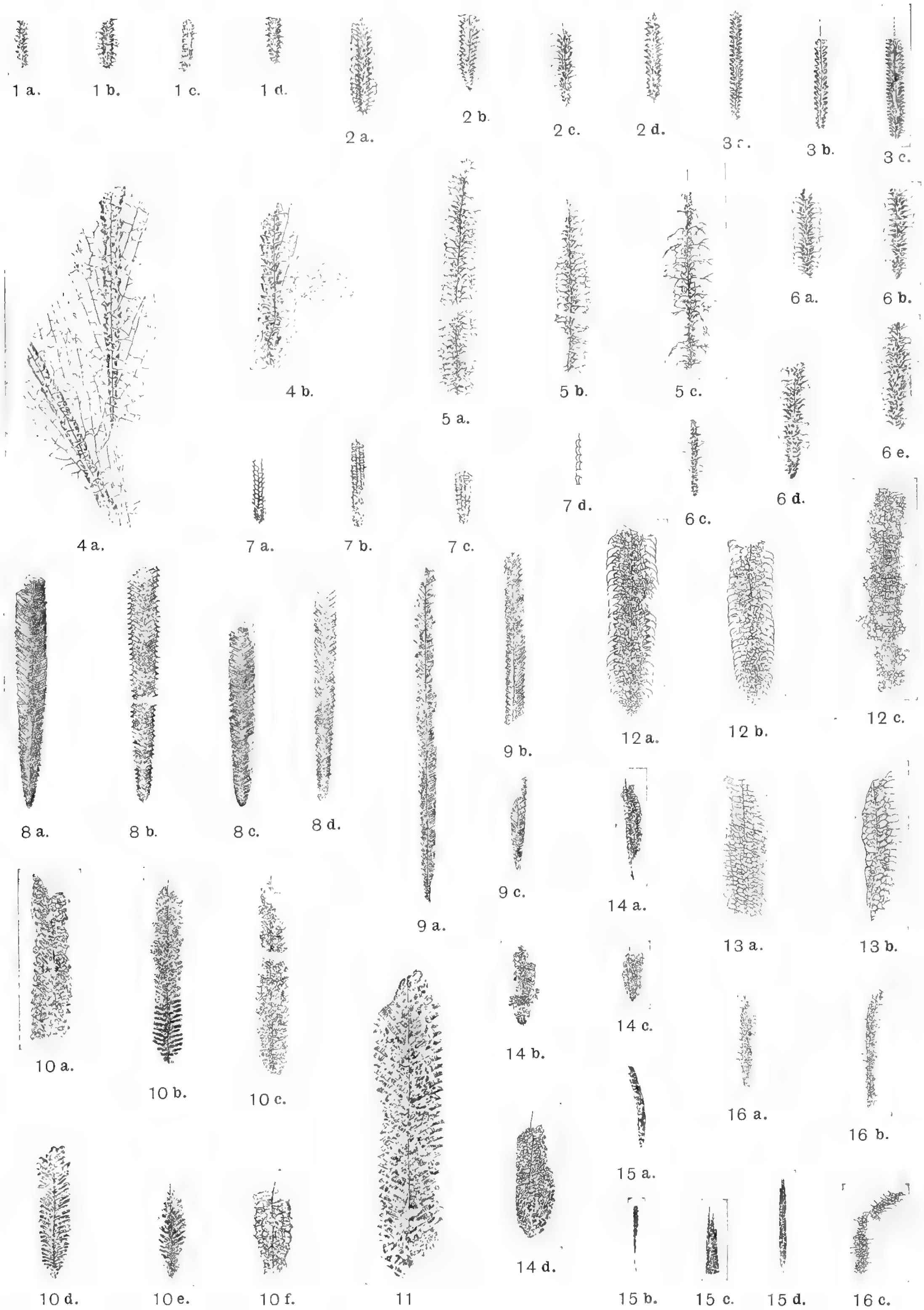
15 *d.* Complete specimen. Ibid.

16 *a—c.*—*Gothograptus spinosus* (Wood). (Page 345.)

16 *a.* Type specimen, figured Wood, 'Quart. Journ. Geol. Soc.,' 1900, vol. lvi, pl. xxv, fig. 29 A. Vicarage Road, Builth. Lower Ludlow Shales. Wood's Collection.

16 *b.* Longer, but less complete specimen. Ibid.

16 *c.* Two specimens in juxtaposition showing effect of cleavage. On same slab as fig. 16 *a.*



THYSANOGRAPTUS, NYMPHOGRAPTUS, NEUROGRAPTUS, RETIOGRAPTUS, GLADIOGRAPTUS, PLEGMATOGRAPTUS AND GOTHOGRAPTUS.

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PLATE XXXV.

Genera **Trigonograptus** and **Dimorphograptus**.

FIGS.

1 *a—c.—Trigonograptus ensiformis* (Hall). (Page 302.)

1 *a*. Typical specimen with sicula? Mosedale Beck, Troutbeck. Skiddaw Slates. Sedgwick Museum.

1 *b*. Distal fragment, narrower. Pont-y-Feni Quarry, 3 miles W. of St. Clears. Arenig. Geological Survey of England and Wales.

1 *c*. Long, narrow specimen. Near Keswick. Skiddaw Slates. Sedgwick Museum.

2. *Trigonograptus ensiformis*, var. *lanceolatus* (Nicholson). (Page 303.)

Type specimen, figured Nicholson, 'Ann. Mag. Nat. Hist.,' 1869 [4], vol. iv, pl. xi, fig. 6. Ellergill, near Milburn. Skiddaw Slates (Ellergill Beds). British Museum (Nat. Hist.).

3 *a—d.—Dimorphograptus confertus* (Nicholson). (Page 349.)

3 *a*. Typical specimen, distorted by cleavage. Skelgill. Skelgill Beds (zone of *Dimorphog. confertus*). Sedgwick Museum.

3 *b*. Well-preserved specimen. Main Cliff, Dobb's Linn. Birkhill Shales (zone of *Orthog. vesiculosus*). Elles' Collection.

3 *c*. Specimen showing sicula and virgella. Urr Water, $\frac{1}{2}$ mile S.W. Nether Glaisters, $7\frac{1}{2}$ miles S.W. Dunscor. Birkhill Shales. Geological Survey of Scotland, Edinburgh.

3 *d*. Well-preserved short specimen. Long Cliff, Dobb's Linn. Birkhill Shales. Lapworth's Collection.

4 *a—f.—Dimorphograptus confertus*, var. *Swanstoni* (Lapworth). (Page 350.)

4 *a*. One of type specimens, figured Lapworth, 'Geol. Mag.,' 1876, pl. xx, figs. 13 *a—c*. Coalpit Bay, Donaghadee. Birkhill Shales. Belfast Natural History Museum.

4 *b*. Another typical specimen on same slab as 4 *a*.

4 *c*. Ibid.

4 *d*. On reverse side of same slab. Ibid.

4 *e*. Longer specimen. Coalpit Bay, Donaghadee. Birkhill Shales. Lapworth's Collection.

4 *f*. On same slab as 4 *e*.

5 *a—e.—Dimorphograptus decussatus*, Elles and Wood, nov. (Page 352.)

5 *a*. Typical specimen. Dobb's Linn. Birkhill Shales (zone of *Orthog. vesiculosus*). Elles' Collection.

5 *b*. Somewhat smaller specimen, obverse view. Main Cliff, Dobb's Linn. Ibid.

5 *c*. Reverse view. Same locality as 5 *a*. Ibid.

5 *d*. Poorly preserved specimen. Same locality as 5 *b*. Ibid.

5 *e*. Young specimen showing proximal end and virgella. On same slab as 5 *a*.

6. *Dimorphograptus decussatus*, var. *partiliter*, Elles and Wood, nov. (Page 353.)

Characteristic specimen. Main Cliff, Dobb's Linn. Birkhill Shales. Elles' Collection.

FIGS.

7 *a—d.*—*Dimorphograptus physophora* (Nicholson). (Page 353.)

7 *a.* Long specimen with disc. Dobb's Linn. Birkhill Shales. Lapworth's Collection.

7 *b.* Similar specimen, sub-scalariform view. Ibid.

7 *c.* Long and narrow specimen, showing sicula but no disc. On same slab as 7 *a.*

7 *d.* Three young specimens in juxtaposition, showing sicula and beginnings of disc. Dobb's Linn. Birkhill Shales (zone of *Orthog. vesiculosus*). Elles' Collection.

8 *a—d.*—*Dimorphograptus cfr. longissimus* (Kurck). (Page 354.)

8 *a.* Typical specimen. Keisley, E. Ridlaw. Stockdale Shales (*Dimorphograptus* zone). Marr's Collection.

8 *b.* Narrow specimen, obverse view. Dobb's Linn. Birkhill Shales (zone of *Orthog. vesiculosus*). Elles' Collection.

8 *c.* Broad specimen. Fruid Water, Tweedsmuir. Birkhill Shales. Geological Survey of Scotland, Edinburgh.

8 *d.* Small specimen. Quarter mile E. of Tarn Hows. Stockdale Shales (zone of *Dimorphog. confertus*). Sedgwick Museum.

9 *a—d.*—*Dimorphograptus erectus*, Elles and Wood, nov. (Page 355.)

9 *a.* Typical specimen, with proximal vesicle. Dobb's Linn. Birkhill Shales (zone of *Orthog. vesiculosus*). Elles' Collection.

9 *b.* Smaller specimen. Ibid.

9 *c.* Incomplete specimen. On same slab as 9 *b.* Ibid.

9 *d.* Complete specimen. Dobb's Linn. Birkhill Shales (zone of *Orthog. vesiculosus*). Elles' Collection.

10 *a—e.*—*Dimorphograptus extenuatus*, Elles and Wood, nov. (Page 358.)

10 *a.* Typical specimen, somewhat distorted. Coalpit Bay, Donaghadee. Birkhill Shales. Belfast Natural History Museum.

10 *b.* Ibid.

10 *c.* Ibid.

10 *d.* Smaller specimen. Main Cliff, Dobb's Linn. Birkhill Shales (zone of *Orthog. vesiculosus*). Elles' Collection.

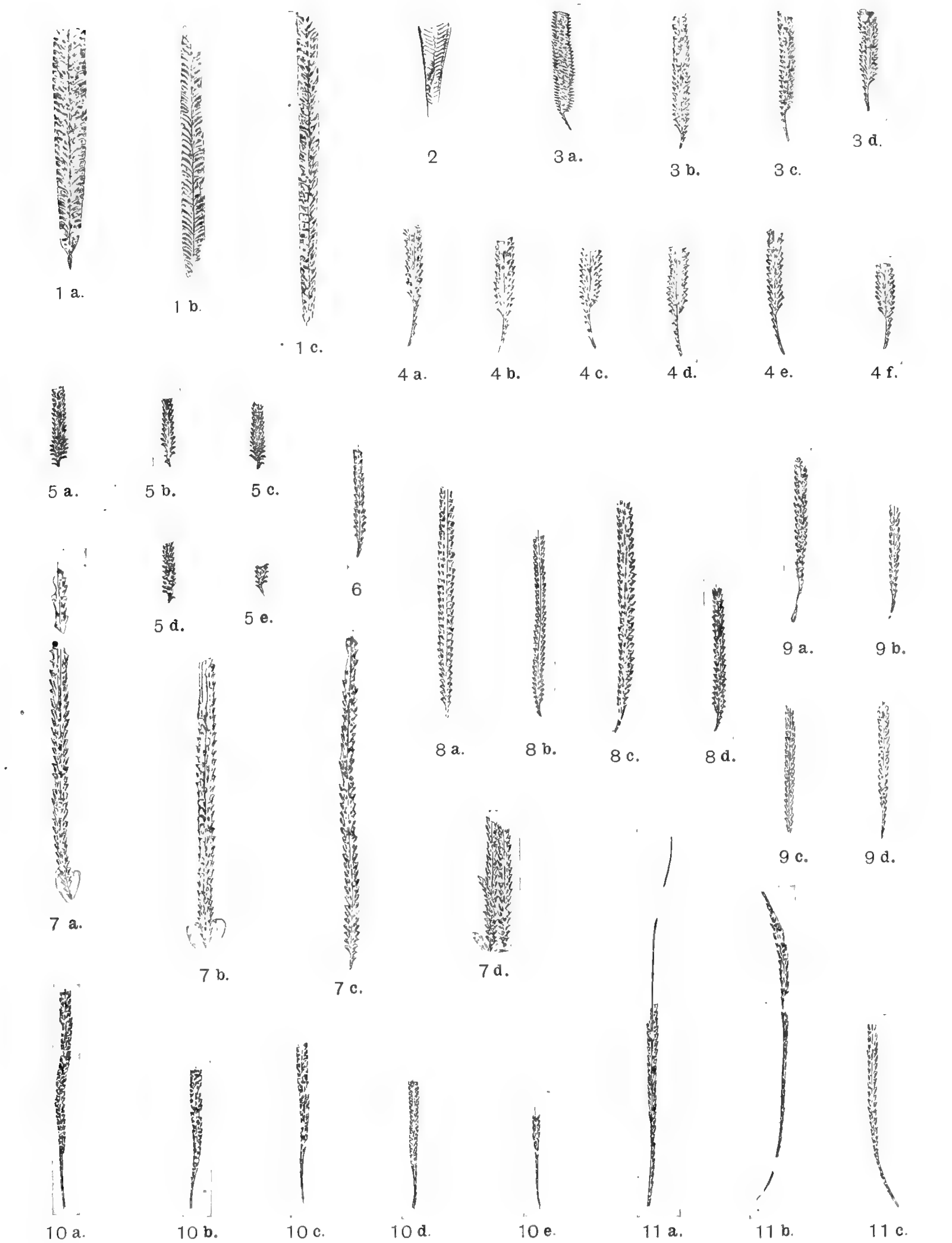
10 *e.* Young specimen. Dobb's Linn. Birkhill Shales. Lapworth's Collection.

11 *a—c.*—*Dimorphograptus elongatus*, Lapworth. (Page 357.)

11 *a.* Type specimen, figured Lapworth, 'Geol. Mag.,' 1876, pl. xx, figs. 12 *a*, *b*. Dobb's Linn. Birkhill Shales. Lapworth's Collection.

11 *b.* Specimen on same slab as fig. 11 *a.*

11 *c.* Smaller incomplete specimen. Dobb's Linn. Lower Birkhill Shales. Elles' Collection.



TRIGONOGRAPTUS AND DIMORPHOGRAPTUS.

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